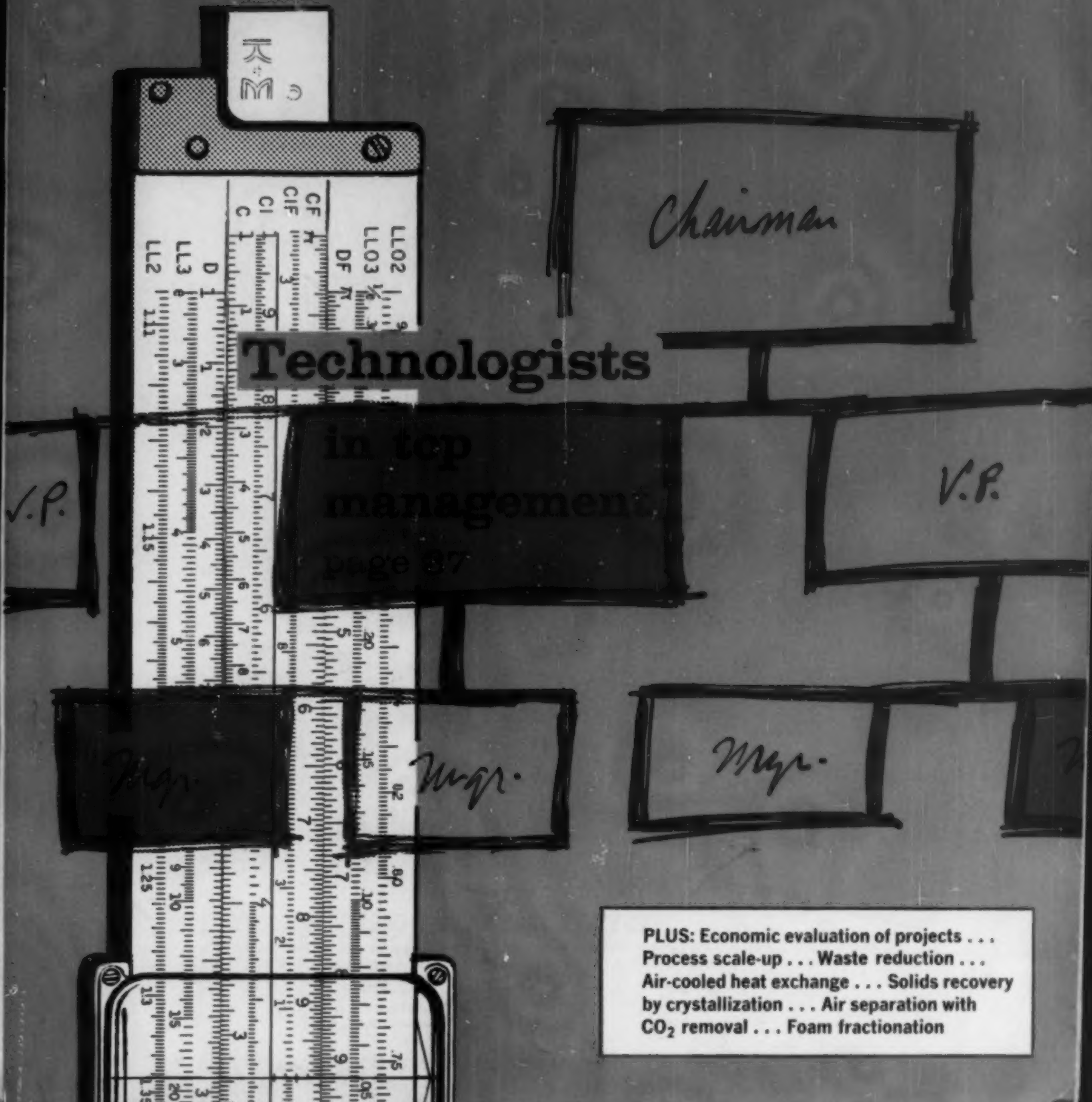
MAY 1959

CEP

CHEMICAL ENGINEERING PROGRESS



Technologists in top management

page 37

PLUS: Economic evaluation of projects . . . Process scale-up . . . Waste reduction . . . Air-cooled heat exchange . . . Solids recovery by crystallization . . . Air separation with CO_2 removal . . . Foam fractionation

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CHEMICAL ENGINEERING PROGRESS
May 1959 — **Volume 55, No. 5**

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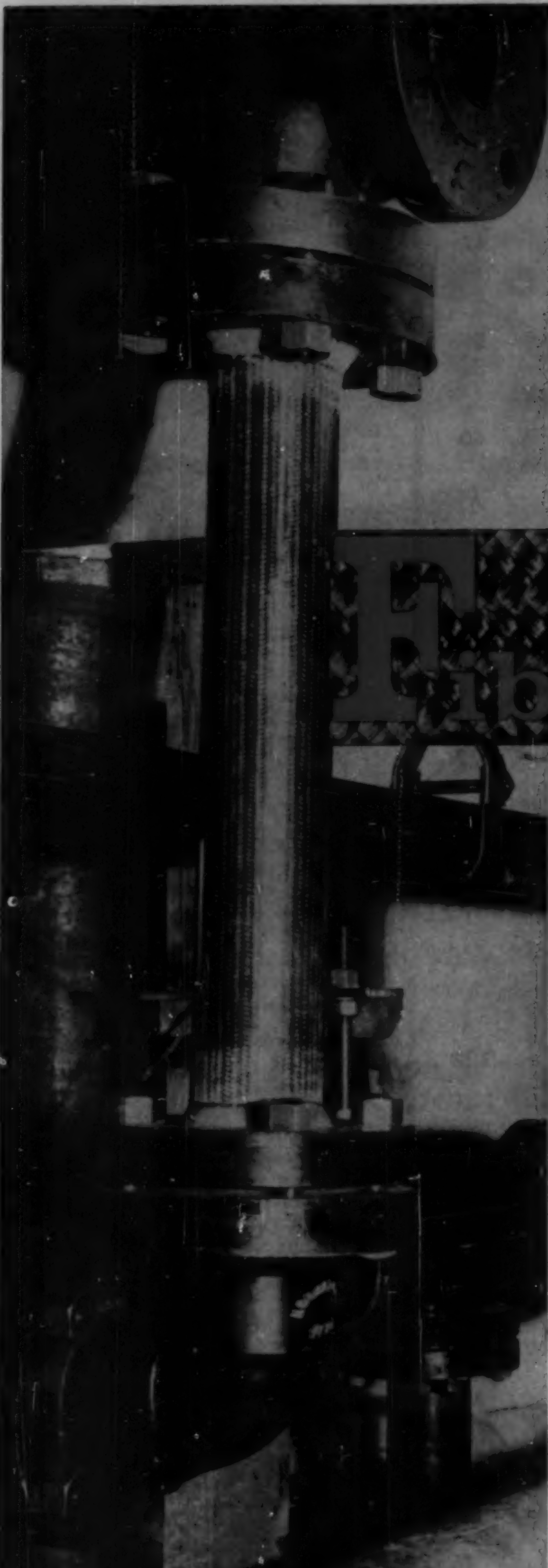
departmental features



in production of spectacular new . . .

TYREX

tire cord

Fibercast pipe

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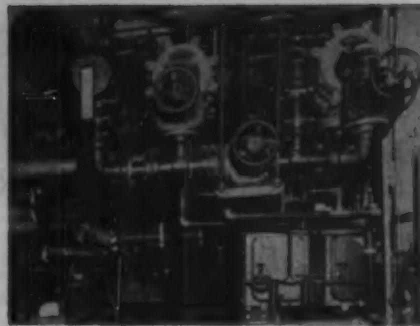
FIBERCAST is a centrifugally cast thermoset Epoxy Resin Reinforced Pipe with multiple layers of seamless braided glass fiber sleeving. The scientific selection of the two materials combines in one integral resin body, the glass fibers perfectly arranged, imbedded and bonded, resulting in high strength and long service life pipe and tubing, capable of high temperature and pressure operations.



Left: Showing the ease of inplant fabrication of Fibercast Pipe and Fittings by plant personnel.

Above: Typical installation of plant fabricated Fibercast assemblies.

Below: Fibercast Pipe drilled and tapped for special application.

easily handles extremely hot, corrosive solutions

Months of laboratory and test-track punishment have proved — the hard way — that Tyrex viscose cord now gives tire makers what they need to produce the toughest, most rugged and long-wearing tires. In the production of this revolutionary new Tyrex cord, a leading producer had to transport corrosive liquids at extremely high temperatures, so hot that the pipe had to be insulated. Solving this problem was Fibercast pipe and fittings made from thermosetting reinforced epoxy resins. They found Fibercast met all the rigid job specifications and enabled quality production at top rates.

Check these features of Fibercast's Piping-Tubing-Fittings and see what they can do to help speed up your processes where corrosion and/or high temperatures present production problems:

- **Operating temperature — 65° to 300° F . . . widest range of any high-strength, non-metallic pipe.**
- **Operating pressures to 1000 p.s.i.**
- **Radius of curvature approximately 10°.**
- **Linear coefficient of thermal expansion 7.06 $\times$ 10^{-6} to 8.25 $\times$ 10^{-6} in./in./° F essentially the same as steel.**
- **Readily handles hot acids, alkali, caustics, etc.**
- **No electrolytic action. A non-conductor . . . accepted by the electrical industry as a superior insulator.**
- **Support spans — nominal 18'.**
- **Light weight and high strength . . . less than 1/4 the weight of steel.**
- **Low coefficient of heat transfer — 3.0 $\times$ 10^{-4} Cal/CM²/sec/CM/° C — saves heat and cold losses in processing.**
- **Out of 338 common corrosive solutions Fibercast handles 320 — service life of Fibercast generally exceeds that of more expensive piping.**
- **3 major systems of joining — standard flanged — cemented — threaded and coupled with complete line of fittings.**
- **Smooth interior with a Hazen-Williams C Factor-147.**

Remember, no other non-metallic pipe has all the desired advantages found in Fibercast. Its unique and exclusive construction, using high quality materials, is processed under rigid controls. This combination results in a high-strength, high-temperature, non-corrosive pipe unequaled in any application.

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For more information, turn to Data Service card, circle No. 87

Processing thermoplastics, Radioactive wastes, AEC pamphlets, among new books

PROCESSING OF THERMOPLASTIC MATERIALS, edited by Ernest C. Bernhardt, Reinhold Publishing Corp., $18.00, 690 pp.

Reviewed by M. F. X. Gigliotti.

Specific treatments of various aspects of plastics engineering have been contributed by nineteen authors, and assembled into a crisp, well organized and significant volume by Dr. Bernhardt and his committee. The second of a series of books on the subject, sponsored by the Society of Plastics Engineers, the book is divided into three sections. The volume deals mainly with the flow behavior of thermoplastics polymers, particularly in the molten or semi-molten state. After a concise, clear treatment of the basic theory involved, it defines and illustrates the various forming processes used to convert these materials into commercial articles.

The first section, "Fundamentals," develops the general theories and formulas applicable to all of the forming processes. Flow behavior, thermodynamics and heat transfer, and mixing and dispersing are covered in individual chapters, each written by a different author. Despite the obvious hazard of discontinuity, and this is true of the entire book, a surprisingly good job has been done by the editors to maintain a constant pace, avoid overlapping, and keep a consistent level of technical detail. This first section on fundamentals strikes a mean between detailed highly-theoretical analysis, and practice. This is continued, more or less, throughout the rest of the book. Sound basic engineering theory is adapted and enlarged to accommodate these particular types of materials and problems encountered in melting, dissolving, pumping, mixing, and handling them in various viscous states.

"Applications," the second section, uses fundamentals to explain and predict the performance of thermoplastic materials as they are transformed via the various forming processes. Excellent descriptions of equipment and examples of engineering practice are highlights of this section. Separate chapters are included on extrusion, injection molding, calendering, mixing and dispersing, sheet forming, forming of hollow articles, and sealing and welding. The chapter on extrusion, edited by J. B. Paton and prepared by four authors, is outstanding; this difficult subject is developed simply, carefully, and comprehensively.

The third section, "Processing Properties," is actually an appendix containing rheological data supplied by manufacturers of thermoplastic resins. It is significant because very little information of this type has ever been assembled before, and because a standard system of units has been used.

The volume is a basic textbook covering an area of chemical engineering practice that had not previously been thoroughly treated in the literature. SPE has made an excellent contribution to our technology by its sponsorship of this volume.

INSTITUTE OF GAS TECHNOLOGY RESEARCH BULLETIN No. 5, *Identification and Determination of Organic Sulfur in Utility Gases*, by D. McA. Mason and Henry Hakewill, Jr. A.E.S. Neumann, editor. 51 pp., $5.00.

This bulletin, fifth in a series, presents analytical methods for accurately determining the types and amounts of organic sulfur compounds present in utility and synthesis gases. The methods described have sufficient sensitivity to permit determination of sulfur compounds present in concentrations of less than one grain per hundred cubic feet of gas. The research and experimental evidence on which the selection of procedures was based are given, and the apparatus and analytical methods are described in detail. The application of the procedures to the analysis of plant gas streams is presented. Information from the literature, and results obtained through use of the recommended procedures by cooperating gas companies are summarized. The appendix includes four pages of half and quarter scale detailed drawings designed for use with the methods described.

VAPOUR-LIQUID EQUILIBRIUM, Eduard Hála et al. Translated from the Czech by G. Standart, Pergamon Press, New York, N. Y. (1958), 402 pp., $14.00.

Consists of three parts. The first part is concerned with theoretical principles and with methods of calculation of equilibrium conditions from various experimental data. The type of problems frequently met in practice are illustrated by numerical examples. The second, experimental part contains a discussion of the elements of measuring technique, with emphasis on less well known but useful instruments and working procedures. A substantial portion of this section of the book is a review of instruments for the direct determination of the equilibrium compositions of the liquid and vapor phases of the system. The third and concluding part is a survey of the literature published on vapor-liquid equilibrium data up to 1947.

SYMPOSIUM ON RADIOACTIVITY IN INDUSTRIAL WASTE WATER, STP 235, 76 pgs., $2.50, ASTM Headquarters, Philadelphia, Pa

These timely discussions, in the form of eight papers, provide up-to-date data for the water technologists, utilities engineer, and others concerned with radioactivity. Problems in the reactor plant itself and in the associated waste water are discussed. Methods of analysis are described including those for radiation hazards.

Three new pamphlets issued by AEC are just off the press. The first, *Technical Books*, is a 40-page catalog which lists and describes 112 books either published by the commission since 1947, or now in preparation. *Popular Level Film List* (22 pages), and *Professional Level Film List* (29 pages), are contributed by the AEC Film Library. Both were compiled to answer queries concerning films pertaining to atomic energy, which are available for short loan periods for non-profit and non-commercial showings only.

continued on page 119

For more information, turn to Data Service card, circle No. 67

These Twin Features Give You Better Drum Filter Performance . . .

1 HY-FLOW Valve

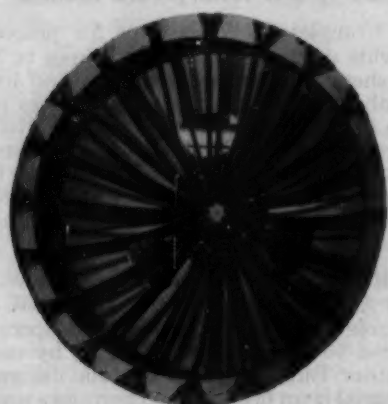
. . . eliminates vacuum loss

Filtrate flow is always unrestricted with Hy-Flow filter valve, developed by Eimco. This new, streamlined valve entirely eliminates all angular passages which caused troublesome turbulence and vacuum loss on flat type filter valves.

With Hy-Flow valve, drum filters operate more efficiently throughout all zones of the filtration cycle. Operators report greatly improved operating economies.

2 E-VAC System

. . . eliminates moisture in piping



Another major improvement in drum filter design, perfected by Eimco, is the E-Vac system of sweeping moisture from piping with air.

Vacuum to lead and trail pipes from each drum compartment is alternately blocked off as drum revolves. Air drawn through pipes sweeps moisture from piping system and drainage deck. No blow-back of filtrate. Result is a dryer filter cake.

The Eimco representative in your area can give you more facts on Eimco's complete line of filtration or process equipment for liquid-solids separation.

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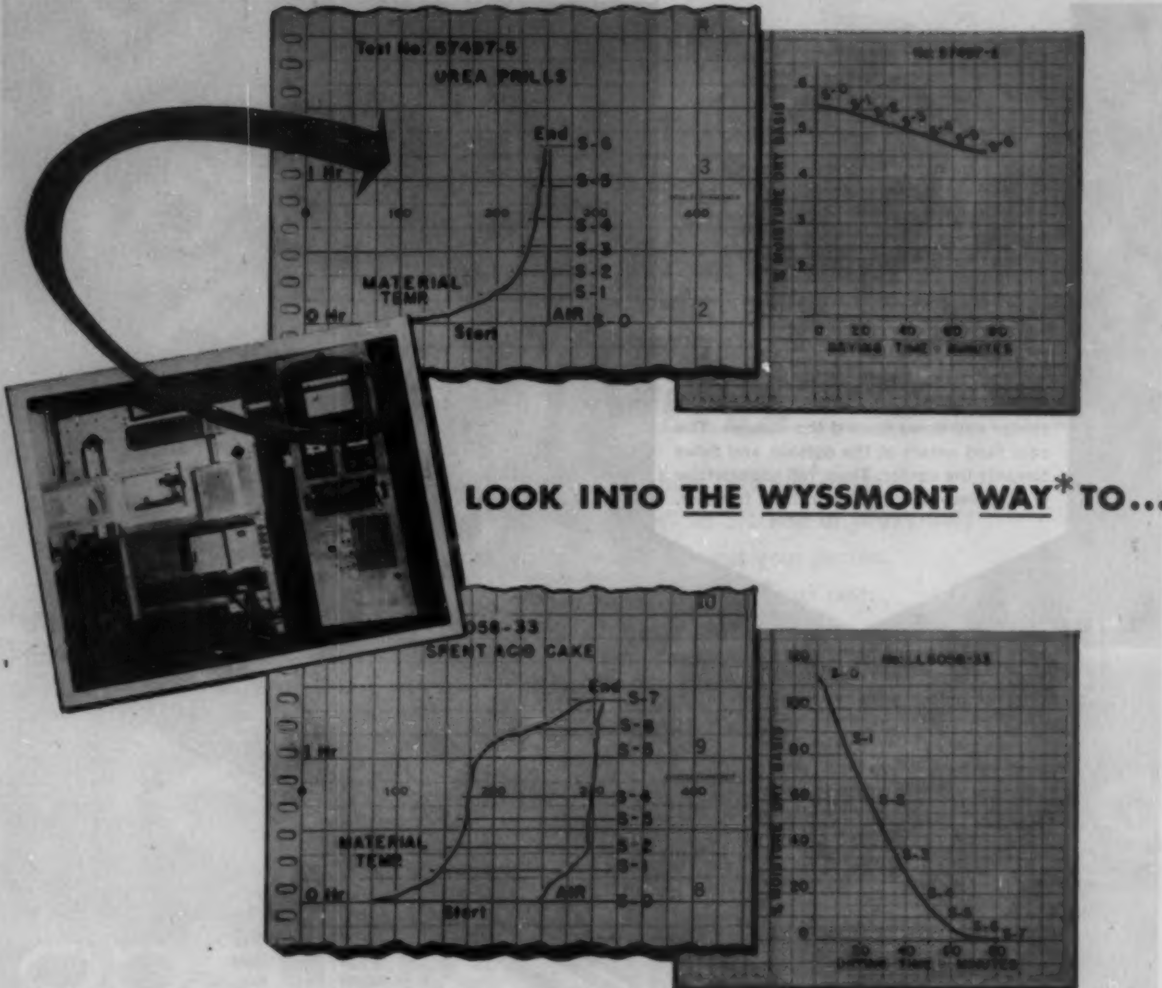
Test No: 57497-5
UREA PRILLS
End
MATERIAL TEMP.
Start
AIR
1 Hr
0 Hr
SPENT ACID CAKE
DRYING TIME - MINUTES

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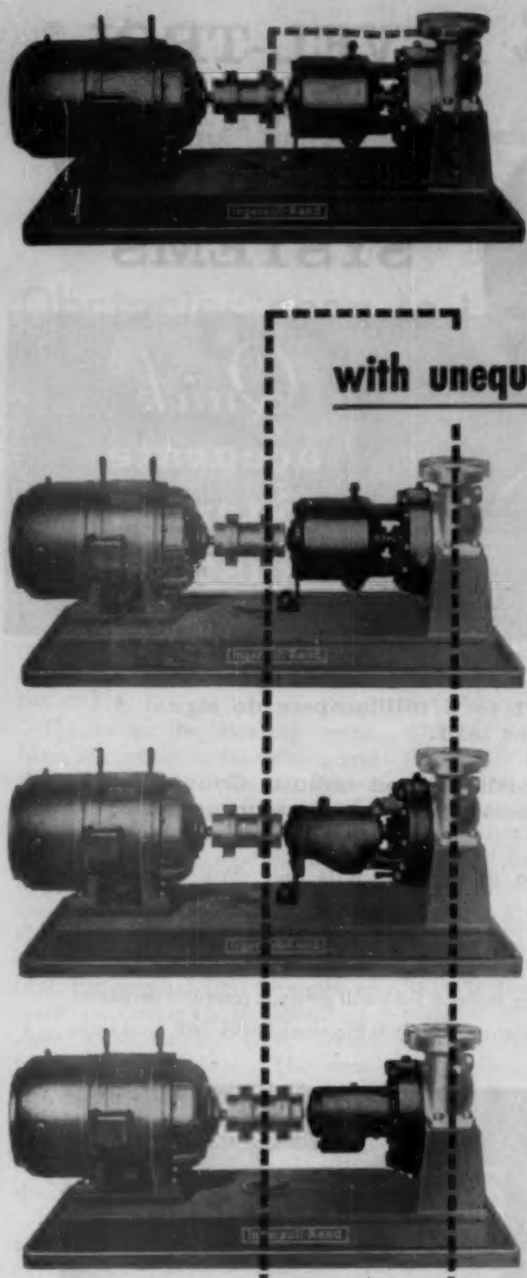
This "multi-process" pump

now handles

a wider range of applications

with unequalled interchangeability of parts



Here's how Ingersoll-Rand "tailors" its SFL line of heavy-duty pumps to meet your process requirements at least cost:

SFL . . . high-temperature service up to 800°F.
This is the basic water-cooled heavy-duty pump which has gained industry-wide acceptance for ruggedness and long-term dependability. It is designed specifically for hot-liquid services and is available with packed box or mechanical seals.

SFLM . . . medium temperature up to 300°F.
Take away the water-jacketing from the SFL and you have the SFLM . . . the same rugged pump *at a lower first cost,* designed for medium-temperature service. Should you later decide to put this pump on high-temperature service, *you can easily convert it to water-cooled operation.* Simply change to a water-cooled stuffing box extension and bearing housing. Available with packed box or mechanical seal.

SFLA . . . up to 200°F . . . with built-in mechanical shaft seal as standard equipment.
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3 designs for one basic pump...
all available with top or end suction for heads to 750 ft, capacities to 900 gpm

WITH Ingersoll-Rand's newly extended line of "multi-process" pumps, you can now select from three basic types . . . and get exactly the pump you want for each specific application. You get maximum interchangeability of parts, plus the first-cost economy which results from a basically *standard* production model.

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THERE'S NO SUBSTITUTE FOR EXPERIENCE IN ENGINEERED PRODUCTS

For more information, turn to Data Service card, circle No. 73

Obstacles seen to U.S.—Euratom accord

Serious obstacles are today standing in the way of implementation of the existing U.S.–Euratom treaty for development of nuclear power in Europe, said Robert Gibrat of France, speaking at the recent Cleveland Atomic Energy in Industry Conference staged by the National Industrial Conference Board. (Gibrat is president and general manager of Indatom, private association of French nuclear companies.)

Thanks to the amazing petroleum discoveries in the Sahara, and the natural gas finds in France proper, pointed out Gibrat, the Euratom countries may, within the next few years, become the world's largest producer of these two fossil fuels. Adding this to the fact that Europe is at the moment suffering acutely from an overproduction of coal, the original 1957 program of Euratom, calling for 15 million nuclear kilowatts by 1965, seems hardly understandable. The present objective of the U.S.–Euratom program—1 million kilowatts—however, is most sensible, continued Gibrat. Where, then, lie the obstacles?

First European complaint, according to Gibrat, is the complexity of the rules being published by AEC. "The lengthy invitation to submit proposals was followed by just as lengthy additions, and later by additions to the additions." The speaker further deplored rumors that beneficiaries of the research and development program will not be allowed to submit bids for the power reactor program. Clarification of the rules of the game is a must, he said.

Economics questionable

In the early stages of the agreement, the European power utilities believed that the idea was to test American reactor designs under cheaper European conditions. Any extra cost over conventional power was to have been shared by the two parties. It seems now, said Gibrat, that the extra cost will be borne almost entirely by the Europeans. "A loan of one hundred thirty-five dollars per kilowatt, at four and one-half percent interest," reasoned Gibrat, "is a small incentive when compared to the extra cost of two hundred fifty dollars per installed kilowatt." Under these conditions, he concluded, Europeans are surprised that they will still be required to prove that the proposed reactors will be economic under local conditions.

The hard sell?

European manufacturers willing to participate in the power reactor program welcomed, according to Gibrat, an opportunity to share with their corresponding American companies the designing of the more difficult parts of the reactors. Many Europeans now maintain that the tendency is to sell American reactors, and no longer to cooperate with costs and profits shared alike. The speaker felt, in addition, that the present deadline for submission of bids, September 1, 1959, was entirely unrealistic, and should be extended for 3 or 4 months—perhaps to December, 1960. This, he contended, would permit thorough cooperative studies between Americans and Europeans.

Patent rights

European manufacturers of fuel elements, while expecting that the first fuel loads will be supplied in whole or in part by American manufacturers, realize that, for financial reasons, subsequent loads will have to be manufactured in Europe under American license. There is, says Gibrat, much speculation as to the effect of the strict guarantee rules set up by the U.S. "For instance," pointed out Gibrat, "how can a French company agree to give up all patentable inventions discovered by it during a ten-year period, in connection with fuel elements entirely engineered in France, for the sole reason that this company has manufactured elements guaranteed by the AEC in agreement with an American manufacturer?"

What is to be done?

The purposes of the Treaty, believes Gibrat, could be better served by a few modifications: extension of certain time limits; relaxation of a few rules concerning patents; simplification of procedures; and a less demanding interpretation of the provisions of the Treaty calling for equal sharing of the extra costs. "These slight changes," he said, "would offset the gradual stiffening of the regulations, which is the major cause for the present uneasiness."

Engineering starting salaries, job offers, up

Number of job offers to engineering students has increased and may go higher, says the College of Engineering, Univ. of Mich. A sampling of the offers indicates salaries are up about five percent, with a B.A. worth about $505 a month, an M.A. about $600, and a Ph.D. about $780.

Soviet sets sights high in plastics

"Under the Soviet regime, chemical production has grown by giant strides, and, in terms of gross production, has already left behind all the countries of the world except the United States. However, in such an important sector as the production of synthetic materials, we are not yet on a par with the industrially developed capitalistic countries. The demands of the national economy for these materials are a long way from being filled."

So says the lead editorial in *Khimicheskaya Promyshlennost* (*Chemical Industry*), organ of the Government Committee for Chemistry of the USSR Council of Ministers, commenting on Premier Krushchev's recent proposals for industrial development in the Soviet Union during the coming seven year period.

"In the course of the years 1959-1965," continues the writer in *Khimicheskaya Promyshlennost*, "we must increase production of bulk plastics and synthetic resins by 6.7 times, of chemical fibers by 3.8 to 4 times, and of synthetic rubber by more than 2.5 times."

Synthetic rubber production will be one prime objective in the Soviet's chemical plans for the next seven years. Quality of divinyl-styrene and divinyl-methyl rubbers will be improved, says *Khimicheskaya Promyshlennost*, while a significant reduction will be made in production of sodium divinyl rubber, which they will supersede. Productive capacity for chloroprene rubber will grow about 6 times, and there will be a manyfold increase in capacity for butyl rubber, brombutyl rubber, divinylmethylvinylpyridine, polyurethane rubbers, etc.

In the realm of synthetics, capacity for phenol-formaldehyde resins and extrusion powders are scheduled for a rise of from 2 to 3 times, while, at the same time, capacity for carbamide and polyamide resins will grow "tens of times." Polyethylene production is slated for a sharp upturn, and other polymers, for instance polypropylene, will be produced "in significant quantities." Increase in production of high polymer synthetic materials, points out *Khimicheskaya Promyshlennost*, will demand a corresponding development in the production of very many other organic materials—basic monomers, dyes, stabilizing agents, surface active materials, solvents, as well as a great variety of inorganic materials – chlorine, silicon tetrachloride, nitric acid, sulfuric acid, titanium dioxide. . . . "There must," says *Khimicheskaya Promyshlennost*, "be about a tenfold increase in capacity for vinyl chloride, raw material for chlorine-based plastics and synthetic fibers, for lacquers, artificial leathers, and many other products."

It is unfortunate that the figures quoted in *Khimicheskaya Promyshlennost* are comparative only; that is, percentage increases are given with no base figure for evaluation of the significance of the increase. (Reliable Russian production figures are hard to come by—Ed.). However, some idea of the magnitude of the Soviet effort can be formed from the fact that they propose to allocate from 100 to 105 billion rubles to development of the chemical industry from 1959 to 1965. Of this sum, says *Khimicheskaya Promyshlennost*, about half will go to construction of projects for production of plastics, chemical fibers, synthetic rubber, and alcohol. These figures should be compared with the estimate of from 1,940 to 1,970 billion rubles for capital investment during the years 1959 to 1965 in all of Soviet industry. (These figures are said to represent an increase of 81.84% over the previous seven-year plan.)

Petrochemical base

Basis for the planned expansion of chemical production in the Soviet Union will be the large-scale utilization of natural gas and of gases engendered in the extraction and refining of pertoleum. Extraction of petroleum is scheduled for a two-fold increase, primary reforming of petroleum will be upped 2.1 to 2.2 times, capacity for catalytic cracking will rise 4.3 times, and capacity for catalytic reforming from 16 to 18 times. Simultaneously, production of gas will increase approximately 5 times, says *Khimicheskaya Promyshlennost*.

Overall goal for the seven-year period is said to be a three-fold rise in chemical production; Chemical equipment and plant will increase by 3.3 to 3.5 times, according to the blueprint. It is interesting, finally, to note that, while production of instruments in general is scheduled for a rise of from 2.5 to 2.6 times, output of calculating machines and computers will go up more sharply—by 3.3 to 3.5 times. *Caveat lector!*

Washington Notes

Loans equivalent to $40 million from the European Investment Bank and the World Bank to the Southern Italy Development Fund, will help to finance the Mecure thermal electric power project south of Naples, Italy, and two industrial projects in Sicily, the SINCAT and CELENE petrochemical plants, both near Augusta. It is reported that the two latter projects, taken together, will form one of the most complete chemical complexes in Europe . . . Support of scientific publications and information services by the National Science Foundation as part of a stepped-up program under its Office of Science Information Service, totaled more than half a million dollars in the first quarter of 1959.

J. L. Gillman, Jr.

Soviet no economic threat says NAM report

Chances that Nikita Khrushchev can, in the foreseeable future, make good his threat to "bury the United States economically" are slim, according to the National Association of Manufacturers, which has just completed a study of Soviet production records and prospects. "Although the Russians have made appreciable, and in some instances amazing productive gains," says the report, "they are not at this time an economic threat to the United States."

The most spectacular failure suffered by the Russian planned economy, according to the report, has been in agriculture. Russian productivity per worker in agriculture, says the report, is only one-sixth to one-twelfth that of American farm workers. About fifty percent of Russia's labor force is still employed in agriculture; this compares with about ten percent in the United States. Even if labor productivity in Soviet agriculture should increase thirty-three percent every five years (as was officially claimed to have taken place between 1950 and 1955), it would take Soviet agriculture until at least 1985 to 1990 to attain the U.S. level of 1955.

Industrial comparison

The planned growth rate of the USSR for the years from 1955 to 1960 was 10% per year. However, Russian economist Eugene Varga, writing in *Fortune* magazine (July, 1957) said—"We think it will be more than 6%." The NAM report goes on to quote *Fortune* magazine—"Assuming the Soviet industry is now two-fifths as large as American industry, and that it will continue to grow at 6% per year, it would not overtake U.S. industry (growing at 4% per year) for nearly fifty years."

The report gives five major factors for the current slowing down of Soviet industrial production: reduced labor force due to low birth rates and a rising in the school-leaving age; the era of confiscating technological equipment and highly-skilled manpower from conquered countries is over, the process has been reversed and the satellite states are now drags on the Russian economy; depreciation and obsolescence will take more and more of Russia's gross investment; the most accessible ores and other natural resources are being exhausted; and an over-all central control of production has brought on a "bureaucratic inflexibility with resulting inefficiency, waste, and duplication."

Manpower shortage

"Of all the factors affecting future Soviet industrial growth," says the NAM report, "there is one which even the Russian planners are incapable of altering. This is a manpower shortage which faces the Soviets for the next ten to twelve years."

Due to the twenty million deaths of World War II, and the low birth rate during and following World War II, continues the report, the number of people reaching working age (15 years) will decline steadily for the next ten years. Between 1956 and 1960 the anticipated growth of the civilian labor force is only 3 million, and about 5 million between 1960-1965.* During this period, the U. S. labor force is expected to increase by 12.3 million.

* *Figures cited from* The Crisis of Soviet Capitalism, *Burck & Parker,* Fortune, *February, 1957.*

Court order ends Monsanto-Central Farmers suit

A suit brought by Monsanto Chemical against Central Farmers Fertilizer, of Chicago, in which Monsanto charged illegal use of its trade secrets, has been settled by an injunction consented to by both parties. Under the terms of the court order, Central Farmers is prohibited from disclosing certain process information claimed by Monsanto as trade secrets, and is enjoined from using the data for 10 years at any of its plants except the presently-constructed Georgetown, Idaho, plant. The case was closely related to a prior action by Monsanto against a former employé, Charles M. Miller, who was charged with illegally taking process information and making this information available to Central Farmers. This prior case ended with a permanent injunction against Miller, which prohibited his use and disclosure of the material.

Merger tide rolls on

Two mergers between companies in the chemical field and companies in the aviation field—one probable, the other possible—are in the news. An agreement has been reached whereby North American Aviation would acquire Foster Wheeler Corp., engineers for the petroleum, chemical fields. Simultaneously, Thiokol Chemical and Marquardt Aircraft announce that discussions are under way as to the possibility of combining the two companies.

SCOPE

Direct conversion of nuclear energy to electricity

First direct conversion of nuclear reactor energy into electric power is reported by the University of Michigan and the Los Alamos Scientific Laboratory. Predicted within five years by R. W. Pidd (University of Michigan) is a cut of about one-half in the cost of building nuclear reactors, important applications to satellites and interplanetary space travel.

With the new technique, electric power is obtained from a nuclear reactor containing a uranium carbide source surrounded by a plasma of ionized cesium gas. At fission temperature, a large electric current is produced which can be "collected" and put to direct use. The scheme is said to be the result of a laboratory observation, made last July, that the substitution of a cesium gas plasma for one of the metallic elements of a thermocouple produced direct current at several hundred times the power of earlier thermocouples.

The experimental plasma thermocouple, tested for the first time in April, 1959, at Los Alamos, is said to be about the size and shape of an "empty fruit juice can." Source of power is a rod about one-quarter inch in diameter and three-quarters of an inch long, containing uranium carbide. This rod is suspended in the center of the cell and surrounded by cesium gas. When the assembly is lowered into the core of a reactor, the neutron flux causes uranium fission heating in the center of the can, while a flow of reactor coolant around the outside of the can drops the temperature of the cesium plasma. The essential requirements of a thermocouple are thus met, and electricity is produced.

Thermoelectric generator

A contract for design, construction, testing, and supplying of a five-kilowatt thermoelectric generator has been awarded to Westinghouse Electric by the Bureau of Ships, U. S. Navy. The generator, which will convert the heat of a burning fuel (probably Diesel oil) directly into electricity, will have a larger power output than any known generator of this type, says Westinghouse. Almost simultaneously with this announcement, Westinghouse researcher Clarence Zener, speaking on April 28 to the 13th annual Power Sources Conference in Atlantic City, predicted thermoelectric generators with efficiencies up to 35% "within the foreseeable future." Such efficiencies, said Zener, will be reached by selecting materials for maximum performance within a relatively narrow band of temperatures, then "cascading" such materials in several stages to cover a temperature range from about 3,500°F down to ambient temperature.

Radioisotopic radio station

Focus of interest at the recent Cleveland Nuclear Congress was radio station W8NPC, broadcasting from the Public Auditorium in Cleveland on radioisotopic power. The display was mounted by AEC to demonstrate the potentialities of the SNAP-III program for development of thermoelectric power.

From Here and There

New $6 million research laboratory for Du Pont's Elastomer Chemicals Dept. is slated for completion by late summer 1960 . . . Fluor Corp. has acquired a majority interest in a Dutch engineering firm, N.V. Ingenieursbureau voor Chemische en Physische Techniek. Ph. J. Schuyvlet en Zoon . . . Contract has been awarded to Weir Ltd, Glasgow, Scotland, for a sea water distillation plant in the Sheikdom of Kuwait. To cost $1,700,000, the plant will provide 2,250,000 gallons of fresh water per 24 hours . . . RW-300 computers will be manufactured in France by Intertechnique under terms of a licensing agreement just concluded with Thompson-Ramo-Wooldridge.

Support engineer segregation in labor legislation

The active support of Engineers Joint Council has been thrown behind efforts to maintain separate classification of professional employees in labor legislation pending in Congress. Particular reference is to the Kennedy-Erwin Bill (S 505) which is now before the House for action. Recommended by EJC is a provision to the effect that a majority of professional engineers must vote for inclusion in any heterogeneous labor union.

Montecatini licenses polypropylene production in UK.

Imperial Chemical Industries and Shell Chemical have taken out licenses under the Montecatini-Ziegler patents for production of polypropylene in the United Kingdom; plant construction will start immediately, say both licensees.

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Prepared by U. S. Industrial Chemicals Co.

U.S.I. CHEMICAL NEWS

May ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1959

First Technical Book On Aerosols Published

For the first time, complete information on packaging products in pressurized containers has been set down in one place — a 411-page book by Herzka and Pickthall titled "Pressurized Packaging (Aerosols)," now being sold.

Chapters give detailed information on propellents, containers, valves, filling methods, laboratory procedures, emulsion systems and perfumes. Graphs, charts and photos illustrate all chapters, which are followed by lists of literature references and significant patents.

Formulations — over 200 in all — are included, on a wide range of products from insecticides and paints to cosmetics, perfumes and foods. Appendices cover common abbreviations, technical terms, trademarks and trade-names, and aerosol producers throughout the world. The book is considered an extremely valuable reference for both research and development and management groups.

New U.S.I. Sales Office Opens in San Francisco

U.S.I. has established a San Francisco sales office, managed by Kenneth Fietz, who has been a representative of the company's New York Sales Division for the past 16 years. The new office, located at 220 Montgomery Street, was created to serve U.S.I. customers in central and northern California, Oregon and Washington. This office is tied in with U.S.I.'s automated communications system through Pacific Coast headquarters in Los Angeles. This will facilitate the processing of orders and messages by the company's offices and plants in all parts of the country.

H^3-Labeled Methionine Gives Clue to Protein Synthesis in Cells

In a recent study of protein synthesis in the cells of adult mice, DL-methionine labeled with tritium (H^3) was injected into test animals and then traced by radioautography methods. Results revealed that the most active protein synthesis involving methionine takes place continuously and independently within the cytoplasm and nuclear chromatin. Very little protein is synthesized from methionine in the nucleolus.

In this particular study, tritium was used as the tracer element because its low β-ray energy allows good radioautographic resolution. Previous investigations with S^{35}-labeled methionine had shown only that this amino acid is continuously being incorporated into protein in all cells. However, the exact distribution of synthesis in the nucleus and cytoplasm could not be determined up to this time because the high β-ray energy of S^{35} prevented good resolution.

U.S.I. Starts Up 75-Million-Lb. Polyethylene Plant at Houston

Low and Medium Density Resins Being Produced by High Pressure Process. Plans Already Underway to Double Capacity.

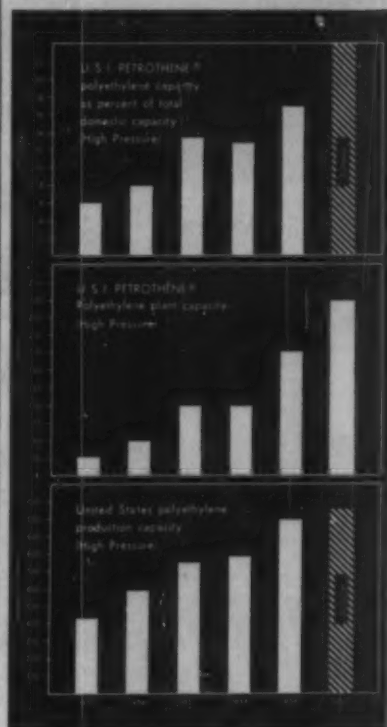
U.S.I.'s new high pressure polyethylene plant has just been put into operation at Houston, Texas, to make 75 million pounds per year of PETROTHENE® resins.

The Houston installation was rushed into production some six to eight weeks ahead of schedule when demand for PETROTHENE resins began to outrun supply late in 1958.

As a result of this demand, a major expansion is already being planned, to double the new plant's capacity and bring the company's PETROTHENE output in Houston to 150 million pounds of high pressure polyethylene per year. At Tuscola, Illinois, U.S.I. now turns out about 100 million pounds of polyethylene annually. Thus, when the planned expansion at Houston is completed late in 1960, total U.S.I. capacity will be 250 million pounds of high pressure resins per year. This will make the company the second largest polyethylene producer in the country.

The new plant is well situated on the Houston Ship Channel for shipment of resins by all means of transportation. Export shipments are facilitated by the extensive port facilities available in Houston. The new installation is assured of a plentiful supply of ethylene — the major raw material — from salt dome storage facilities.

MORE



Oils Solubilized in Alcohol By New Patented Technique

Drug and cosmetic manufacturers can now formulate water-clear, non-aqueous products containing both oils and low-molecular-weight alcohols, via a new solubilizing technique described in U.S. Patent No. 2,865,859 issued recently.

According to the patent, it has never been possible commercially to prepare cosmetic or industrial solutions containing these alcohols plus large quantities of oil. Layering has always taken place. The technique described makes miscibility possible by including low-molecular-weight aliphatic alcohol esters of high-molecular-weight fatty acids.

Mixtures of esters such as ethyl laurate, butyl myristate, amyl oleate, propyl linoleate or isopropyl palmitate are cited. The resulting solutions would contain 20-50% oil, 20-50% low alcohol and 5-20% ester. The oils may be of any class — animal, vegetable or mineral — and the alcohols preferably in the one to five carbon group, such as ethanol, methanol and isopropyl alcohol.

Suggested formulations are given for cosmetic compositions which are claimed highly stable over a wide temperature range for long periods, without separation. Examples include sun-screening compounds, hand lotions, hair preparations, soaps, colognes, antiperspirants and after-shave lotions.

Other suggested fields of applications include metal working compounds, coatings, dry cleaning fluids, hydraulic fluids, biocides and lubricants.

NaK Basis of Prefab High-Temperature Test Loop

A high-temperature test loop, which uses NaK (sodium-potassium alloy) as the circulating medium, is now available as a package unit for research and study purposes.

The loop, designed for 1,000° F, can be employed to examine NaK's natural circulation characteristics, to study oxygen solubility in the alloy, to analyze flowmeter and pump performance, expansion treatment and piping arrangement, to investigate corrosion, mass transfer and metal stress, to design heat exchangers, and to develop pumps.

The unit consists of heaters and coolers, heat exchangers, EM pumps and flowmeters, cold trap, plugging indicators and instruments.

May ★ U.S.I. CHEMICAL NEWS ★ 1959

CONTINUED **Polyethylene**

Other Resins Under Consideration

The company is now producing low density (.913 – .924) and medium density (.925 – .929) resins at the Houston unit. However, extensive research work has been done on the new high density polyethylenes and a process has been developed which is believed superior to any now used, both from a product quality and production cost standpoint. The process has not yet been commercialized due to the current market conditions on high density materials. U.S.I. is also studying polypropylenes and other polyolefins in pilot plant, and hopes to have more to say about them later in the year.

In less than four years U.S.I. has advanced from a nonproducer of polyethylene resins to its present position as third largest producer in the field. Commencing with an output of 26 million pounds in 1955, production increased to 50 million in 1956, 100 million in 1957, and now 175 million pounds. When the contemplated expansion at Houston is completed, the company will have realized a total increase in production capacity of some 900% since 1955.

Product storage silos at U.S.I. polyethylene plant, Houston, Texas.

Film Grades a Specialty

Although U.S.I. makes a full line of resins for all applications, much of its growth in polyethylene has been based on special efforts to develop improved coating and film grade resins. Recently the company pioneered a technique for producing crystal-clear cast film. This material has excellent potential in the huge bread wrap field and other large-volume overwrap markets.

Tailor-making resins for specific purposes was originally and still is one of the distinguishing features of U.S.I. as a polyethylene producer. In all, the company markets some 70 resins today, each varying somewhat in melt index, density, strength, clarity, gloss, slip, stiffness and other properties.

Gas-producing area at Houston plant.

Two New Aerosol Formulas Contain Anhydrous Alcohol

Two new formulations — one for a white shoe polish, the other for a stocking-run stopper — have been developed by one chemical manufacturer for consideration by aerosol packagers.

The run-stopping spray consists of equal parts of anhydrous ethanol and a fast-drying adhesive, plus propellant, coloring and perfume. The formula is said to be nonflammable, and is considered stable, although stability tests have not been completed as yet. Recommended filling pressure and method of application are given.

The shoe polish spray — containing an ethanolic solution of PVP/VA, a sebacate, titanium dioxide, glycerine, isopropanol, acetone and propellant — is claimed to eliminate messy handling and to allow easy touch-up. Filling techniques, valve types and pressure are suggested.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

Radioactive crystalline C^{14}-L-glutamine can now be obtained for in vivo studies of blood-brain barrier permeability and biological utilization of glutamine by brain and other organs. Specific activity of product is 27.8 μc/mg. **No. 1470**

New carbon-monoxide-poisoning test kit now on market determines extent of CO poisoning in a minute by testing exhaled air or in under five minutes by testing blood sample. Color change in treated silica gel indicates % CO in blood. **No. 1471**

Reactor fuel technology is covered in new, 120-page volume now being sold. Includes papers and discussion on economic fuel selection, blanket fuel systems, types of uranium systems, types of fuel elements, cladding and canning. **No. 1472**

Phosphorus pentasulfide safe-handling practices are described in 14-page safety data booklet which can now be purchased. Discusses hazards, protective equipment, containers, waste disposal, first aid, medical care. **No. 1473**

A circular, slide-rule-type of device, which predicts whether a chemical reaction is possible for 10,000 different chemical equations, is now available to chemists and chemistry students. Complete use instructions given. **No. 1474**

Refined ethylene of 99.5% minimum active-ingredient content is described in new data sheet now being offered. Data includes specifications, properties, shipping information, uses plus references on use as ripening agent. **No. 1475**

New analyzer, said to determine amounts of over 20 amino acids in a protein hydrolysate in only 22 hours, is described in new brochure. Results claimed consistent within 2-3%. Typical run shown. Specifications given. **No. 1476**

Cold caustic pulping of mixed hardwoods is detailed in technical report now offered. Includes complete process description, equipment data, flow sheet, quality control tests. Discusses results of studies on pulping variables. **No. 1477**

Niobium and its compounds are described in new book now being sold. Chapters cover sources, supply, economics, extraction, separation, metal preparation, impurities, properties, plating, alloys, reactions, nuclear uses. **No. 1478**

Over 125 radioactive measuring instruments are listed in new 76-page catalog. Detecting, counting and recording instruments are described. Included are systems for research, medicine and education. **No. 1479**

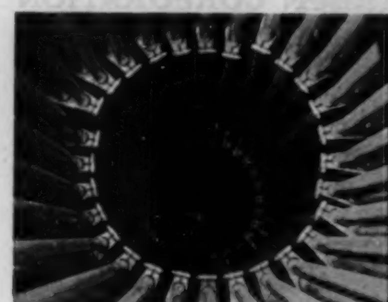
The extraction plant of Runnels Gas Products Corporation at Eunice, La., processes more than 300 mmcf. of pipeline gas daily to yield 5,000 barrels of liquid hydrocarbons (all the natural gasoline and butanes, 96% of the propane and 35% of the ethane.) Fuel-gas consumption is less than 3%. Absorption takes place at -40°F.

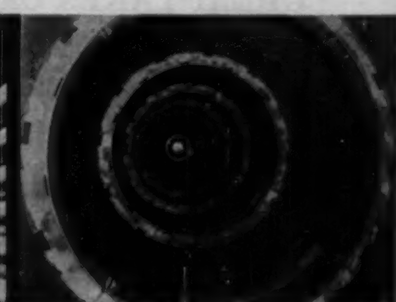
What's new in gas processing?

Anyone contemplating construction of a natural-gas processing plant, whether its purpose is treating, extraction or a combination of both, must first solve a puzzle with three complex variables. The efficiency and profitability of the plant depend on how well the puzzle is solved.

The first variable is, of course, the volume and composition of the inlet gas stream. The second is the market, if any, for extracted products, and the third is the legal and technical requirements for residue gas.

Major shifts in these variables make it profitable today to design gas-processing plants that differ radically from those built only a few years ago, and to locate them much farther away from the gas fields.





about our authors

Technologists in Top Management is the second of a two part article by **K. M. Watson,** professor of chemical engineering at Illinois Institute of Technology. (See page 37).

Ernest Hart *(Technologists in Management)* is president of Food Machinery and Chemical Corp. (See page 37).

Donald B. Keyes (*Participation of Technologists in Management)* is an engineering consultant with offices in New York City.

(l. to r.) Authors Schnepf, Gaden, Schonfeld

Foam Fractionation: Metals, is the result of collaboration between **Robert W. Schnepf, Elmer L. Gaden, Jr., Ella Y. Mirocznik** and **Ernesto Schonfeld.** Gaden's interests in the apparently dissimilar fields of biochemical and nuclear technology are merged in this work on foam separation. He is American editor of a newly established research journal in the fields of applied biochemistry and microbiology. Schnepf and Gaden are with Columbia University Department of Chemical Engineering. Ella Mirocznik and Schonfeld are associated with Radiation Applications, Inc., New York firm which specializes in work on foam separation.

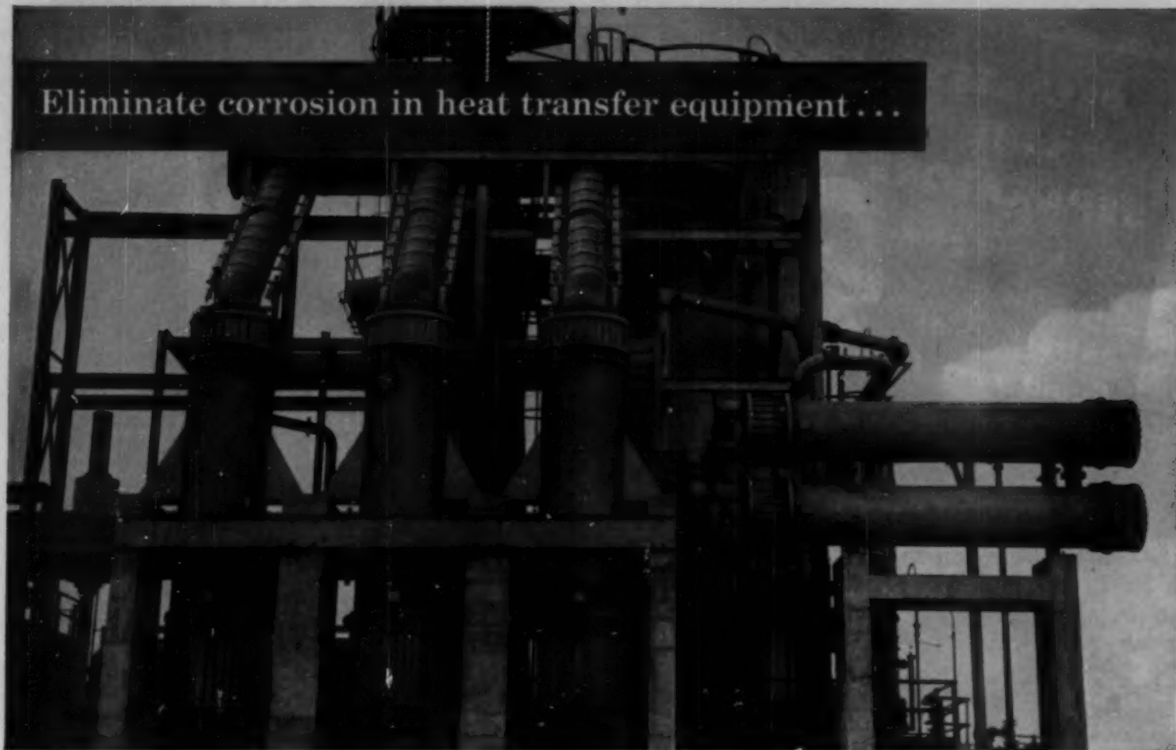
(l. to r.) Authors Svanoe, Tallmadge, Walker

Hans Svanoe *(Solids Recovery by Crystallization)* has worked in the chlor-alkali as well as synthetic ammonia industries. He has been in the United States since 1919, representing AS. Krystal Co. of Norway in this country for several years until he made an arrangement with Struthers Wells Corp. whereby the Norwegian firm's patented equipment was to be designed and fabricated by Struthers Wells. Svanoe is at present manager of the Crystallizer Department at Struthers Wells.

One of R. A. Sullivan's (*Pilot Plant Production Synthetic Quartz)* major activities has been heading groups

continued on page 30

For more information, turn to Data Service card, circle No. 36



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90	6"	9	17.7	26.5	35.4	—	—
190	8"	19	37.3	55.9	74.5	87.0	99.5
310	10"	31	45.6*	91.2	121.6	141.9	162.2
420	14"	42	81.7	123.3	164.8	192	220
640	16"	64	124.3	187.7	251	293	335
850	18"	85	165.2	250	334	389	444
1090	20"	109	213	320	427	499	570
1350	22"	135	263	397	530	618	706
1630	24"	163	317	479	640	746	852
1950	26"	195	379	573	766	892	1017
2330	28"	233	453	684	914	1065	1217
2680	30"	268	521	786	1051	1225	1400
3490	34"	349	679	1024	1368	1595	1822
4390	38"	439	855	1289	1722	2009	2295
5960	42"	596	1162	1749	2336	2727	3118
6850	45"	685	1335	2010	2685	3135	3585

*This unit has 4½' long tubes.

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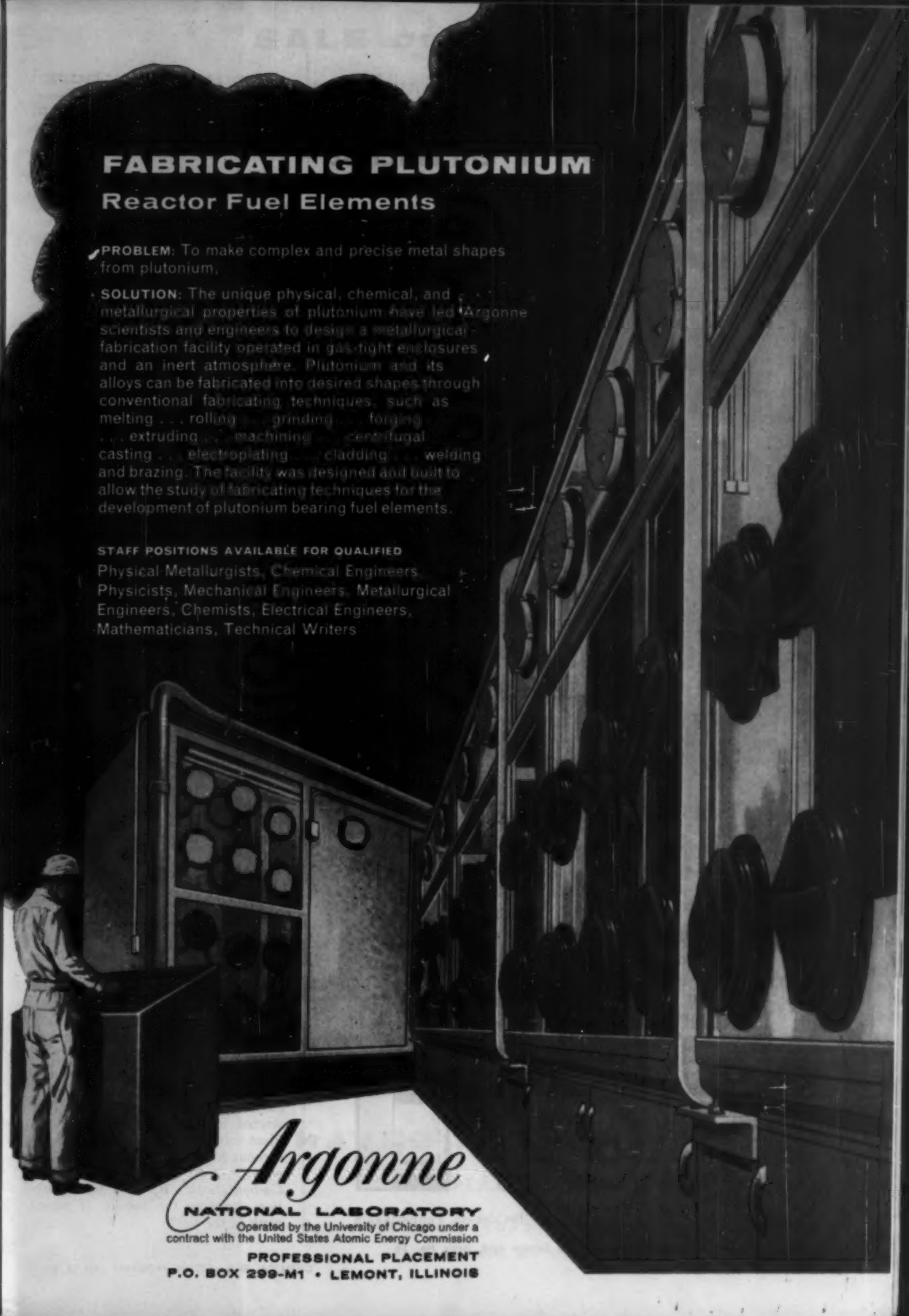
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about our authors

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which set up and ran a quartz pilot plant. He is located at the Merrimack Valley Works of Western Electric, at North Andover, Mass. **R. A. Laudise**, who worked with him on the project, is on the technical staff of Bell Telephone Laboratories. Laudise, who has a PhD in inorganic chemistry from MIT, has done research on crystal growth and hydrothermal crystallization.

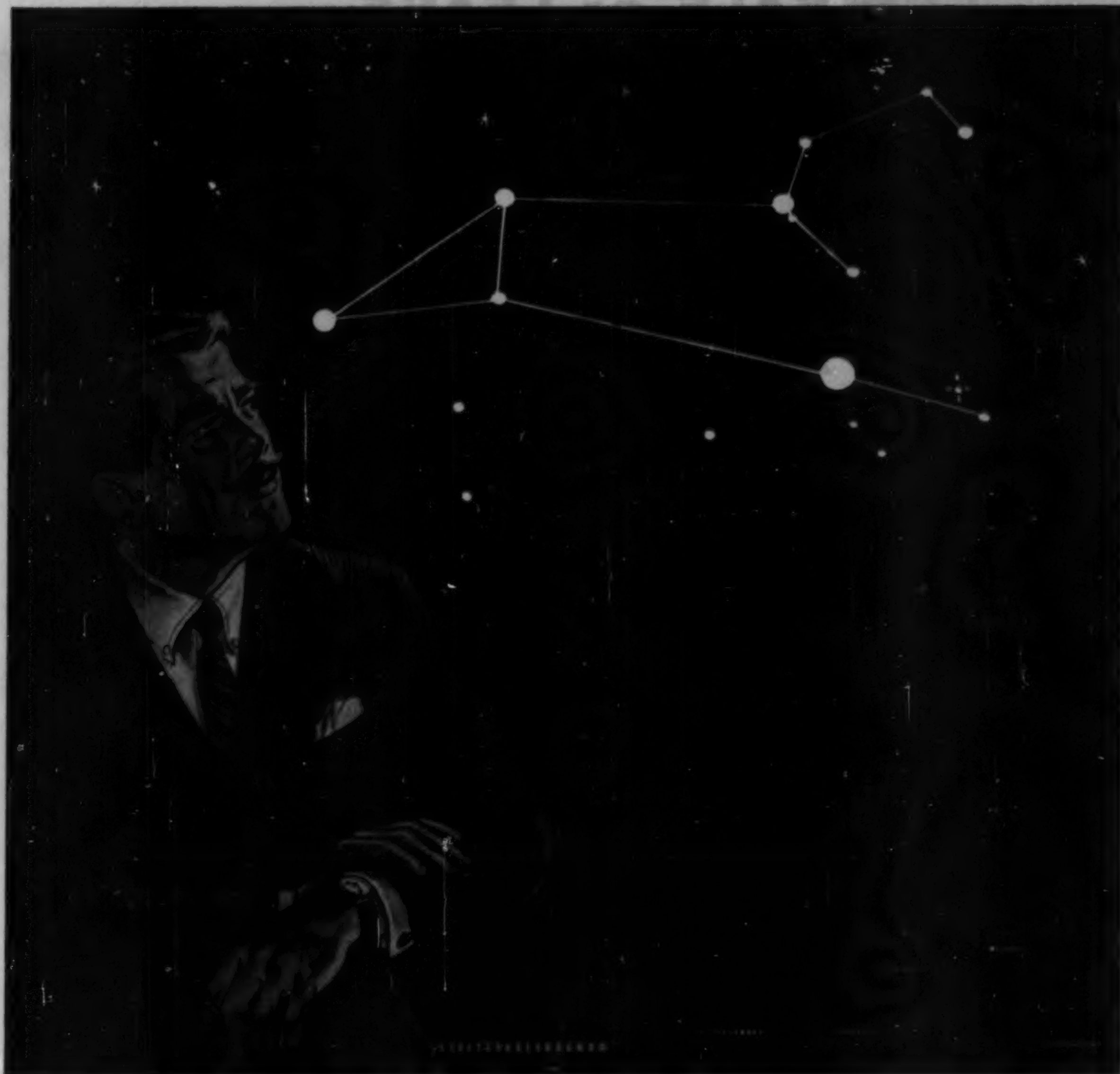
Ralph T. Mathews (*Air Cooling in Chemical Plants*) has, for the last few years, concentrated on new design development work at Du Pont in his capacity as senior power consultant. He was formerly assistant principal power engineer for the design division of the company. Mathews also taught Mechanical Engineering for several years at Duke University.

(l. to r.) Authors Mathews, Laudise, Sullivan

C. A. Stokes *(Organization and Coordination of Economic Evaluation)* says that perhaps the most rewarding experience of his life has been the unique opportunity afforded him to set up an economic evaluation function in as near an ideal way as possible. This was made possible with the inception of Texas Butadiene and Chemical Corp., a firm of which he is now vice president. While most of Stokes' contributions have been in the field of management of research and development, he has also worked extensively in the less publicized field of carbon black technology.

Charles A. Walker and **John A. Tallmadge**, who contributed the article, *Metal Finishing Waste Reduction*, are members of the Department of Chemical Engineering at Yale University. They have been engaged in research on waste disposal and pollution abatement, working closely with the Connecticut State Water Commission, and with various industrial concerns.

Ernst Karwat of the Linde Company, Munich, West Germany, is not a newcomer to the pages of CEP. He has written in recent issues, on Oxygen Plant Safety and on aspects of Hydrocarbons in Air Separation Plants. His current contribution, *Air Separation-Carbon Dioxide Removal by Adsorption*, presents the results of recent work in the field.



For more information, turn to Data Service card, circle No. 20

Inflation—plague or destiny?

For as long as most of us can remember, the prices we pay for commodities—whether plant equipment or items for the home—have been rising. We are all aware of the dramatic rise in prices that has taken place since World War II. Some economists have termed this inflation a necessary evil that accompanies full employment and high wages. Others are frankly worried that we may be heading for a runaway inflation that could do serious damage to our economy.

For those who have the responsibility of appropriating 1959 dollars for capital expenditures, the return on which will not be realized until 1962, or even 1965, the value of today's dollars *then* is a matter of some serious concern. Should one buy now as a hedge on inflation, should long term labor contracts be made which anticipate checking of the inflation, and if the value of the dollar is to be stabilized, should financing for expansion be in the form of debt or equity? These are some of the questions raised, and in effect answered, in a recent issue of the Chemical Economics Newsletter* (CEN).

The only projections available on the future of the dollar, says CEN, are based on a conviction that the continued full employment to which government policy is committed, is unattainable without inflation.

Current policy to combat inflation is for the most part directed at influencing the supply of money and the velocity of its circulation (money supply, times velocity of circulation, equals gross national product). This policy is derived from the historic experience that is, in brief, as follows: between 1929 and 1946 the money supply increased much more than did the economic activity or price level. Compensating factor was the velocity of circulation. Since 1946, however, the velocity has been rising—and this has undoubtedly been responsible for much of the price rise, since increases in the money supply have lagged behind economic activity.

The velocity of circulation, according to CEN, reached a peak of 4.1 in 1919; it stood at 3.2 in 1957, and if it follows the postwar trend, will again reach 4.1 by 1965. With increases in velocity limited by the same conditions that have kept the velocity below the 1919 peak of 4.1, control over money supply should be an effective means of checking a rise in price level.

A gross national product of $575 billion is predicted for 1965. If velocity of circulation did reach the assumed limit of 4.1 by 1965, the supply of money required would be $140 billion—which is $3.2 billion less than the supply in June, 1958. Or, if the velocity of circulation would level off halfway between the 3.2 level of 1957 and the 4.1 assumed upper limit, the supply of money would be about $160 billion, a total increase slightly less than has occurred in the past seven years. Thus, if the money supply shows a tendency to increase at a much faster rate than about $2.7 billion/year (as it already has in 1958), further inflation is to be expected unless the velocity of circulation shows a marked tendency to level off.

Three factors are cited by CEN as complicating this analysis. *One*—inflationary forces which create pressures on fiscal and monetary authorities to allow the money supply to expand. For instance, wage and price increases require an expanded money supply to support them. *Two*—the argument of many economists that economic growth with full employment is not attainable without some degree of inflation. *Three*—interaction between the supply of money, its velocity of circulation, and the level of economic activity. If, for example, growth of money supply and velocity of circulation are successfully curbed, economic activity (measured in employment or constant dollar gross national product) might also be curbed.

In spite of these complicating factors, CEN advises close watch on treasury and Federal Reserve Board activities which affect the money supply—as giving a fairly good idea of what is likely to happen to the price level.

* *Permission to quote from the CEN has been granted by Stanford Research Institute, Menlo Park, Calif.*

Engineering Progress Report

FROM UNION CARBIDE CHEMICALS COMPANY

Acetonitrile boosts butylene throughput 58%, saves $3,000,000 capital investment

Unusual solvent useful in saturate-unsaturate and olefin-diolefin separations

By using acetonitrile as an extractive distillation solvent, Shell Chemical Corporation has boosted throughput of the existing butadiene feed-preparation unit 58% in their Torrance plant. Minor engineering changes for the unit cost $148,000: it has been estimated that a similar throughput increase through new construction would cost about $3,000,000. Development work and operating experience have shown that acetonitrile's unusual solvent properties should prove useful in other saturate-unsaturate and olefin-diolefin separation processes.

ADVANTAGES OF ACETONITRILE

Acetonitrile has boosted capacity in the Shell plant because it increases the spread in boiling points of the C_4 hydrocarbons being distilled. Thus, separation of the hydrocarbons is more efficient than with either acetone or furfural. Relative volatility of n-butane compared to butene-1 is about 1.25 with acetone and about 1.30 with furfural. Acetonitrile increases this ratio to almost 1.4. The spread in boiling points of butene-1 and butadiene is also increased. The table gives data on the relative volatilities of C_4 hydrocarbons in aqueous acetonitrile systems.

After the extractive distillation has been completed, acetonitrile can be completely recovered from the butane and butylene streams with greater ease than acetone. This increased recovery efficiency is due to the high distribution coefficient of acetonitrile in water/hydrocarbon systems.

ENGINEERING CHANGES MINOR

Because of the similarity of the physical properties of acetonitrile and acetone, it is not necessary to change the operating pressure of extractive distillation columns. Shell engineers made only minor changes to their unit. Besides a larger reboiler and a new pump, two heat exchangers were switched and the solvent recovery column was connected to vacuum operation. Aqueous acetonitrile systems do not foul exchanger systems. Corrosion due to hydrolysis of solvent at reboiler temperatures is minimized by pH control.

TABLE 1 RELATIVE VOLATILITIES OF THE C_4 HYDROCARBONS IN AQUEOUS ACETONITRILE, 120 psia

	Total Solvent Concentration, 80%m		Total Solvent Concentration, 85%m	
Component	Water in Solvent 15%m	Water in Solvent 25%m	Water in Solvent 15%m	Water in Solvent 25%m
Isobutane	1.638	1.673	1.637	1.674
n-Butane	1.332	1.347	1.348	1.368
Isobutylene	1.013	1.013	1.013	1.013
Butene-1	**1.000**	**1.000**	**1.000**	**1.000**
t-Butene-2	0.861	0.856	0.865	0.861
cis-Butene-2	0.821	0.813	0.827	0.820
Butadiene-1, 3	0.639	0.599	0.645	0.604
Water	0.08	0.045	0.075	0.045
Acetonitrile	0.043	0.033	0.043	0.033

OPERATING COST REDUCTIONS

The butadiene feed-preparation unit operating on acetonitrile has less solvent-loss than one operating on acetone. *Thus, solvent make-up costs are no higher with acetonitrile than with acetone.* Steam and pumping costs have also been reduced because reflux and circulation rates are lower. This is true even at reduced feed rates.

ACETONITRILE USEFUL IN OTHER PROCESSES

Acetonitrile is effective in other saturate-unsaturate and olefin-diolefin separations. This heat-stable extractant is useful in ethylene-ethane, propylene-propane, and cyclopentadiene-cyclopentane separations. The boiling point spreads between pentadienes, such as isoprene, and pentenes are also increased.

In liquid-liquid extraction processes, acetonitrile is effective in removing tars, phenols, and color bodies from hydrocarbons. Acetonitrile is also useful as a selective solvent for fatty acids.

INFORMATION AVAILABLE

If you're looking for increased efficiency in your extractive distillation or liquid-liquid extraction processes, acetonitrile could be the answer. Detailed information on acetonitrile as an extractive distillation solvent along with information on azeotropic mixtures of acetonitrile is available. For this information, call the nearest CARBIDE Technical Representative—or write, Department B, Union Carbide Chemicals Company, 30 East 42nd Street, New York 17, New York.

Nothing herein shall constitute a recommendation to practice any invention covered by any patent without permission of the patent owner.

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opinion and comment

To be Understood

"At present there is a great lag in the ability of people to understand and appreciate new scientific developments," according to Chauncey D. Leake, president-elect of the AAAS, who, in a recent luncheon talk, urged scientists to translate what science is about, and what it is doing, into language people can understand. Dr. Leake, an Ohio State University physiologist, suggested that even poetry might be used to help organize scientific ideas. He read to the assembled group a "cadence" about thermodynamics and evolution, as follows:

From all the vast
unbounded sun-lit space about
come fragments of an energy
to catalyze our life,
to make the green of plants
and in a mystic liturgy
of ordered chance,
to change another gene,
which may produce,
if viable, a kind
of different living thing,
which must, if it survives,
adapt itself to others, as all
of them shall find.
Here in this systemed neat
evolving scheme of everything,
Time's Arrow points the way inflexibly
nor can we shift a dot
of its position, nor its movement stay,
nor though we read
the sign-post fairly well,
to what it points, have we the wit to say.

Our reason for reporting Dr. Leake's views and his poetry is to draw attention to applying the same basic thinking to the growing problem of "how does the 'practitioner' group within a profession keep abreast of what its fellow 'scientist' group is accomplishing at the frontiers?"

The chemical engineering practitioner of today is literally surrounded (in industry) by specialists of various sorts. First, there are the chemical engineering specialists. Then, the operations researchers, accountants, decision-making aides, human relations experts, long range planners—each group with a sizeable vocabulary understood largely only by its specialist members.

We cannot, today in particular, afford to let knowledge stand around unused. Yet, with fundamental knowledge being developed at a faster rate than ever before, we should be concerned over whether communications techniques are keeping up with needs.

Two basic solutions readily suggest themselves: either the practitioner should begin to learn the new jargon vocabularies, or the specialist should write so that larger audiences of practitioners can understand what he is saying. Although the choice is more or less up to the individual concerned, it is the purpose of this writing to lend encouragement to those who write understandably. Or did we make our point clear?

J.B.M.

Technologists in top management

part 2

Some technologists wish to be only technologists. Others see in managerial roles a better outlet for their desires and energies. The chemical engineer, a particularly broad-thinking technologist, was, a few decades ago, largely an entrepreneur, a founder of many of today's process industries. Now, in today's industrial organization, the chemical engineer is often regarded as prime top-management material—if he is fortunate enough to have the mysterious quality of leadership along with his sound knowledge of processing technology.

That more chemical engineers should prepare themselves for, and direct their aspirations toward, top management roles, seems almost too obvious to require the emphasis given here. Perhaps the justification lies in what every young technologist soon finds out—that entree into upper echelons is often a difficult task that requires skill in dealing with people, plus a certain amount of willingness on the part of top management to accept up-and-coming technologists as equals.

Professor Watson, in Part I of this two-part series, described his system for rating company "success," and correlated such "success factors" with the presence or absence of technologists in the upper echelons of the companies' managements.

Here, in the pages that follow, is the more significant interpretation and discussion that Watson and others recently presented. Clearly, their remarks are aimed not only at technologists, but also at top management—Editor.

Speaking for technologists:

Kenneth M. Watson, professor of Chemical Engineering at the Illinois Institute of Technology, who contributes his second article to the CEP series on the place of the technologist in modern management.

Speaking for management:

Ernest Hart, president of Food Machinery and Chemical Corporation, has held various executive posts in his company for many years, is a former chairman of the board of MCA, has had long experience in studying the technologists in management.

Technologists

coordination

communication

Kenneth M. Watson
*Illinois Institute
of Technology, Chicago*

In Part 1 (2) of this study a statistically significant relationship was demonstrated between business success and the level of technological activity of forty large petroleum and chemical companies. It was found that over 25% of the officers and directors of these companies are technologists.

There can be no doubt that technologists do a great deal for business and that business does much for those technologists whose abilities and inclinations lead them into executive positions. However, the business and technological success of a company is to a large extent dependent upon the productivity of its technologists at the working level. Here are found many highly creative and economically perceptive individuals whose primary interests are not in administration. In their hands is the ultimate responsibility for technological success or failure. The rewards of business to these creative individuals vary widely with different management attitudes and policies.

It is generally recognized that the rewards for which a creative technologist strives include both job satisfaction and money. Frequently the former is the more important. Both are likely to be related to the success of the employer. Thus the greatest good can come from improvement which will simultaneously improve the status of the technologist and improve the probability of business success.

Personnel and organization

In correlating business success with technology *(2)* three basic factors were designated as probably more important than either technology or size. Variations in these factors are believed to account for the striking exceptions to the general correlation. The *ability and enthusiasm of personnel at all levels* is of such obvious importance as to merit little discussion. Exceptional ability on the part of key individuals can make effective utilization of limited levels of technological activity and achieve success with apparently unbalanced situations. However, loss of even one individual of the genius category can seriously impair the progress of an organization formed to be unduly dependent upon him.

Effectiveness of organizational patterns and procedures is the result of constant vigilance on the part of every executive, technologist, supervisor and worker to reduce costs, improve efficiency and expand markets. A company may have able personnel, good technology and large size but still show a poor record of success. It is certainly possible for management to be undesirably unbalanced by technological domination at the expense of economic and financial viewpoints. However, there is also the possibility that a long-established company, like an individual, may grow fat and lazy with excessive costs creeping in all along the line. Such situations may be corrected quickly by a change in top management to provide the aggressiveness which will develop the latent possibilities of the organization.

Internal communications

Of greatest importance to the technologist are the methods of internal communication of both technological and economic information on a company-wide basis.

Technology is so broad a field that success can be achieved only by highly selective direction of available effort into the channels most likely to lead to success. Such selectivity is possible only when technological information is communicated to and understood by financial specialists and when economic data and objectives are available to and understood by technologists.

Unfortunately, there are no published data by which the internal communications of a company can be measured. It is well known that many of the most successful companies devote much attention to development of communications. Well-balanced management teams are formed on which every viewpoint is represented to insure communication. Information, objectives and ideas are communicated on a company-wide basis by meetings, interchange of reports, and personal contacts. Under such a system, technologists participate effectively and secure, or can develop for themselves, the leadership necessary for success and job satisfaction.

On the opposite extreme are companies in which communication barriers are deliberately maintained by top management. (i.e. directors and officers having company-wide authority.) Heads of manufacturing and marketing departments are forbidden to exchange data. Technologists are barred from pertinent economic data.

in management

Heads of research and development organizations are forced to operate with a knowledge of company policies and objectives gained largely by reading the press. It is ironical that while maintaining barriers of this type, a management may proclaim great interest in communications, even to the extent of organizing courses in communications for junior executives.

Two types of motivation have been observed for exclusion of technologists from management and maintenance of communication barriers. One is a feeling of uncertainty on the part of a non-technical management confronted by technological problems. In order to support its dominance, communications are so restricted that no individual outside of top management ever has full information. The other motivation is an honest conviction of the superiority and infallibility of the traditional businessman top management.

It is believed that in many companies improved internal communications offer the greatest single opportunity for improving both business success and the status and rewards of technologists. Improvement is necessary on both sides of the technological-economic barrier which divides many companies. Technologists must give increased attention to presentation of reports and proposals in terms intelligible to non-technical executives. On the other hand, many top-management executives must show greater willingness to share information and plans which have been considered privileged.

Recommendations

1. Technologists should give more attention to a thorough understanding of business principles in order to prepare themselves for effective participation in business. Much communication difficulty results from lack of a common language for the expression of business and technological ideas in terms comprehensible to all.

2. Non-technical managements whose success record is not good should give increased attention to the

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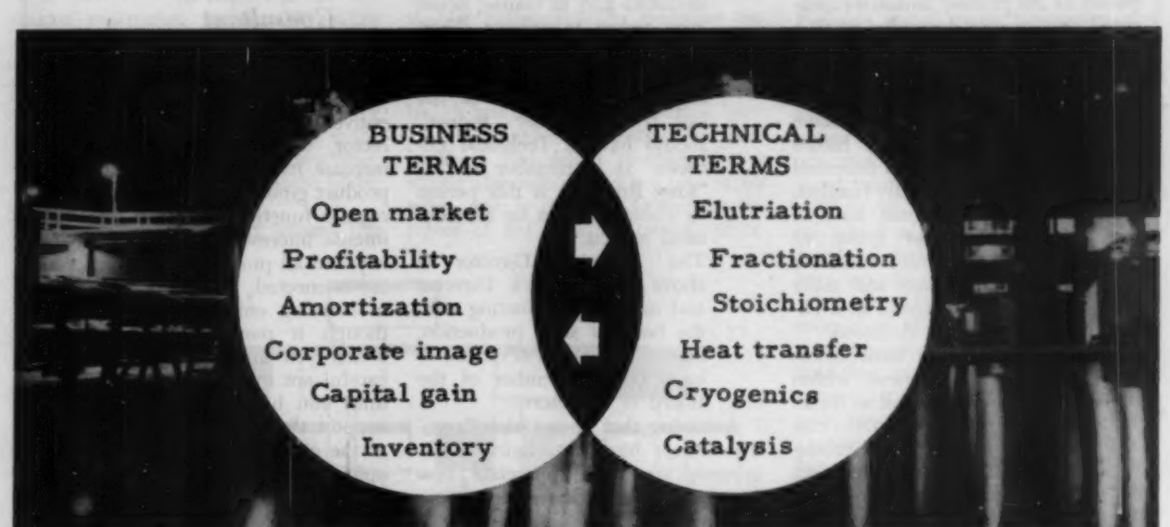

Two-way communication between technologists and business associates is vital in any company. Each must know and understand the others operations and problems.

Coordination and communication

continued

technological point of view and try to understand and assimilate it rather than exclude it. One productive step in this direction is establishment of a staff activity for economic evaluation of technological projects on a company-wide basis by some of the procedures discussed in the literature (*1*) (*3*). This is a technological activity which is entirely beyond the scope of any accounting organization. Many companies have large organizations comprising the highest types of scientists and technologists engaged in such activities.

3. In selecting employers technologists should attempt to evaluate, by all possible means, the internal communication situation of the prospective employer. In addition, careful consideration should be given to the type of published information on which this study is based. This does not mean that employment opportunities are necessarily best in large compaines of the size included in this study. The study was restricted to large companies because of greater availability of data and reduced dependence on luck or chance.

Neither should it be concluded that only successful companies are good employment risks. The greatest opportunity may lie in an unsuccessful company that is about to correct the situation. However, such correction must start at the very top of management. Since individuals rarely change, corrective moves can be expected only as a result of major personnel changes in top management. It is difficult to appraise statements of intent because currently everyone is for technology in the same way that everyone is against sin.

LITERATURE CITED

1. Happel, John, "Chemical Process Economics", John Wiley, New York (1958).
2. Watson, K. M., *Chem. Engr. Progr.* 55, 37-44 (1959).
3. Watson, K. M., *Ind. and Eng. Chem.*, 50, 594-8 (1958).

Participation of technologists in management

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A careful study of over fifty companies in the process industries indicated that success depended upon a realization by top management of the importance of the following three suggestions:

1. Top management must have definite plans for the future with which their top technical people are thoroughly familiar.
2. The company must have a highly competent group of technical economic evaluators to collect the facts and make the necessary digests as a basis for top-level decisions.
   This group must have access to every department within the company, as well as direct contact with potential customers, raw-material producer, etc. They collect the facts, write reports showing the pro's and con's and undoubtedly influence the top command in their decision, but these evaluators *never make decisions* and, of course, *never give orders to anyone*. They have a purely staff function.
3. The Chief-Executive officer, regardless of whether or not he is technically trained, should have a Technical Director as a member of his "King Row." It is this person to whom he looks for all technical advice.
   The Technical Director is above the Research Director and on an equal footing with the head of sales production, finance, etc. It is advisable to have him a member of the Board of Directors.

Assuming that your Chief Executive Officer has no technical background, you will appreciate how important these three suggestions become.

Let us assume that you are neither your company's Chief Executive Officer nor its technical director, what can you do to help increase its profits and maintain its product growth over and above your regular function? You can show an intense interest in the evaluation of any and all projects with which you are connected. Always offer to help in carrying out these studies even though it means extra work for which you are not paid. Be very careful not to express your opinions until you have substantial data to support them. Always ask questions of the other fellow and listen to his opinions.

These evaluation studies are usuallly difficult, often frustrating, but frequently fascinating and sometimes highly profitable.

Opportunities in management for the technologist

ERNEST HART
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The chemical industry is a *technical* industry. Those chemical companies in this industry which have provided the proper quota of technically trained men in their management groups have been the most successful

Not all technically trained people are ambitious to get into management. The exceptions, of course, are those dedicated scientists who prefer the rewards of achievement and contributions to progress to the higher pay, and greater hazards residing in the management function.

To those technically trained men who have ambitions to participate in management, I wish to say that while technical training is not a prerequisite to management success, it certainly is a useful tool in climbing the ladder to management participation.

If one is in a hurry to reach the top drawer of management in any major enterprise, he should realize that the course is tough and he should know that statistically the average age of chief management executives now encumbent in American industry is close to sixty. The road to management is exciting and rewarding, but it takes time to cross home plate, to use a baseball analogy.

The process of moving around the bases, however, is being speeded up in recent years due to the fact that management is recognizing that technically trained or other candidates for management berths should be spotted earlier than in the past and are being given opportunities to develop training and experience in management in addition to their other duties.

One of the outstanding examples of this is the current practice of sending company men from all categories, including those technically trained, to business school courses, such as Harvard, Columbia and many others at company expense. The purpose is to broaden their knowledge of administrative practices, to create an atmosphere where they can participate with others in the solving of hypothetical management problems as well as practical business and administrative matters. Technically trained men with ambition to participate in management should enthusiastically embrace opportunities of this nature.

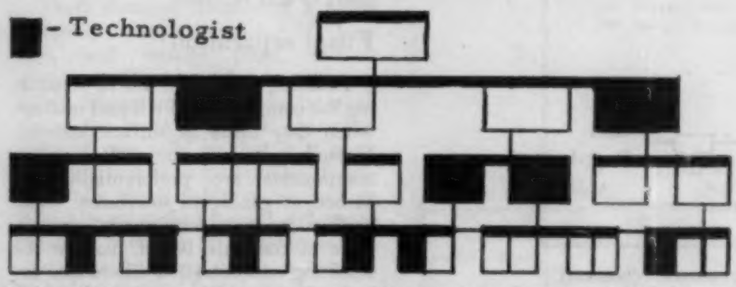
Major prerequisites for those who aspire to management are: robust health and a strong constitution. Average intelligence or better, is axiomatic. I also might mention that a strong alimentary tract is a plus factor when one is required to endure the rigors of the banquet circuit, entertainment and traveling which have become so important a part of management lore. Long hours, high responsibility, interference with normal family life, tension, stress and strain and a reasonable amount of worry frequently go hand in hand with management jobs. They sometimes constitute a health hazard.

There are one or two other considerations which should be pointed out to those technically trained people who aspire to management. These are that they must have that indescribable something said to be the quality of leadership. They must be experts in communication. They must have integrity, courage and character. They must be dedicated to our free enterprise system and they must have a keen sense of social responsibility.

The day of the hard fisted, rugged individual in management is rapidly going the way of the horse and buggy. Perhaps some small businesses can still be successfully administered by such an individual. However, most of our large business enterprises have found it necessary to create a mechanism for other than one-man management. This we call the management team.

The management team is a device by which all major segments of the business find representation in one way or the other. Here indeed the value of and the opportunity for the success of technically trained men in management is outstanding. In this field lies, in my opinion, the greatest opportunity for technically trained men, ambitious to participate in management and of course, once a member of such a team it is always possible for one to land in the chief executive position, and this has frequently occurred in our industry.

There is always lots of room at the top.



Today, there is room at every level of business management for the technologist.

Foam fractionation: metals

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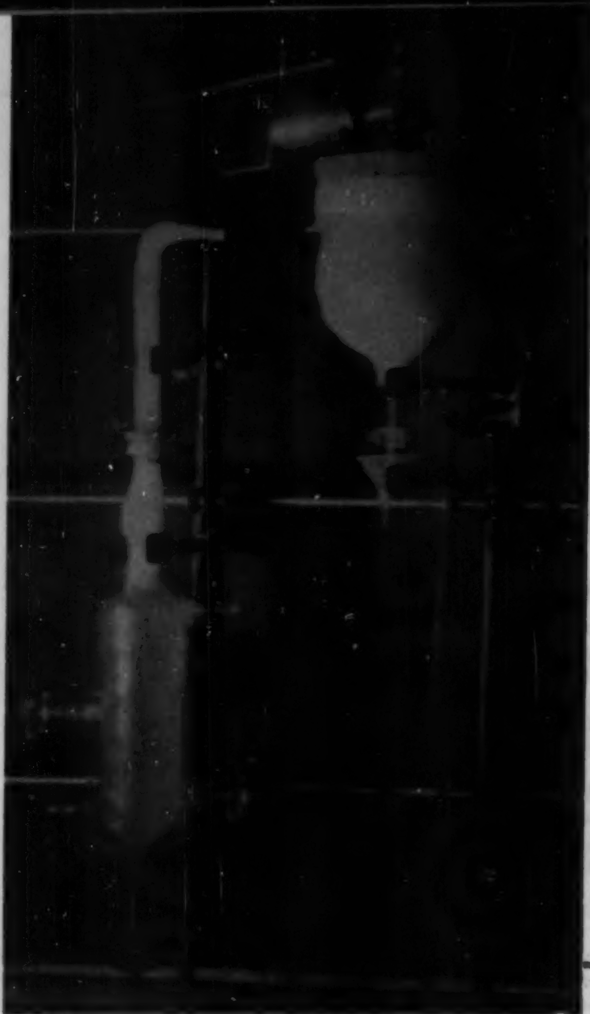


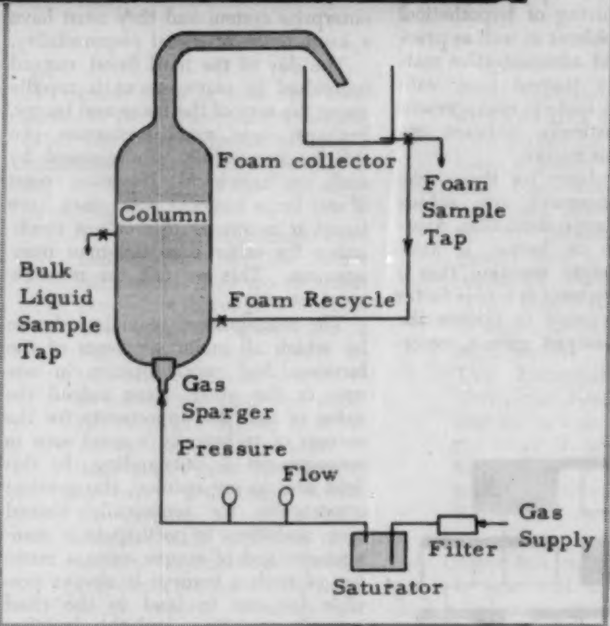


Figure 2. Foaming apparatus (top), schematic (bottom). The mechanical foam breaker, not visible in the picture, is mounted in the collector.

There are many instances in the CPI where the presence of small concentrations of particular cations is critical. One example of current concern is the removal of specific components, especially strontium and cesium, from radioactive wastes (*1*). A number of common removal methods are applicable such as; chemical precipitation, extraction, adsorption, and ion exchange. However, because of the low concentrations involved and the extreme complexity of these waste streams, these methods have not proven completely satisfactory. In the search for new techniques, foam separation, (peculiarly suited to low-concentration ranges), has been applied to this problem.

Foam separation

Foaming offers a means of separating the components of a liquid mixture when they differ in surface activity. In such a mixture the surface active components are preferentially adsorbed at gas-liquid interfaces, while surface inactive components concentrate in the bulk liquid. To use the resulting concentration-differences between surface layers and the bulk liquid, the region near the liquid

According to the results of this detailed study, the most important factor in determining the success of a particular application of metals separation by foaming seems to be the proper choice of foaming-complexing agent.

surface must be rapidly removed and collected.

Foaming offers ease of operation and relatively large capacity, compared to other methods of "surface collection." The foam, with its large surface-area to liquid-volume ratio, is the *agent* which "collects surface" and separates it from the bulk liquid.

When a liquid containing surface-active materials is foamed, the most positively adsorbed (i.e. most surface-active) components are selectively concentrated in the foam while surface-inactive substances collect in the bulk liquid. For most purposes the effectiveness of foam separation can be expressed in terms of an *enrichment ratio*; the concentration in the foam, divided by concentration in the bulk, or residual, liquid. The theoretical basis for foam separation has been outlined, with a study of the general effects of operating variables, by Kevorkian and Gaden (2).

Foam separation is often confused with froth flotation, an old, established procedure in mineral dressing. Although mechanically similar (both involve the gassing of a liquid mass to bring about separation of the components) the two are different in principle.

Froth flotation deals with a heterogeneous system involving at least two, and usually three, distinct phases; a liquid and two different solids. Separation is achieved by modifying the particle surface characteristics of one solid so that it is more readily attached to air bubbles. Fundamentally, froth flotation employs an artifically magnified density difference between particles of different solids; analagous in principle to separation by sedimentation, hydraulic classification, etc.

Foam separation, on the other hand, is used to separate the components of a single homogeneous liquid phase; a true solution. It is closest in principle to distillation, extraction, and ion exchange.

The most advantageous feature of the foam separation technique is its effectiveness at low concentrations. It can be theoretically predicted, and has been experimentally verified (3), that the enrichment ratio increases as the solution becomes more dilute. Thus, foam separation is of greatest value in the region where other methods run into economic limitations.

Foam separation of metals. In general, solutions of metal ions are not surface active. Hence the foaming of such solutions should yield no enrichment. To use foaming techniques for the separation or enrichment of metals, the metallic ions must be made surface active. To accomplish this the metals in solution must be associated with some surface active material such as anionic surface active agents, organic chelating and complexing

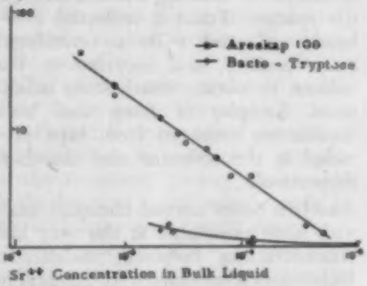


Figure 1. Preliminary foaming experiments.

agents, or other negatively charged materials exhibiting surface activity.

The agent used to remove a particular metal ion from solution must have two characteristics, it must be surface active, or form with the metal a compound which is surface active and, it must have some preferential attraction for the metal to be removed; an attraction exceeding, or at least (in some cases) equalling that for other cations in the solution. The first requirement is not difficult to fulfill; a vast number of surface active materials and chelating agents are available.

The second requirement is not so easily satisfied for all metallic ions. To illustrate: consider a solution of Na, Ca and Fe salts from which it is desired to remove the Ca. The presence of Na should present little difficulty since almost all chelating or complexing agents have a much greater attraction for Ca than for Na. The presence of Fe, however, complicates the situation since most known chelating and complexing agents preferentially attract the Fe rather than the Ca ions.

Whether or not a particular agent will remove a given ion from solution depends on many factors; the presence of other ions, their concentration, the relative stability of complexes formed, and the foaming power of the agent. Because of the large number of possible combinations of these factors in cases where foam separations appear attractive, few generalizations can be made regarding the procedure to follow in a given case. Each application must be investigated separately.

There are two mechanisms whereby a metal in solution can be enriched by foaming. It may form a surface

continued

Foam fractionation

continued

active complex, chelate, or other compound with the addition agent, or it may be electrostatically attracted to the surface (foam) by a negatively charged surface active agent. The first method is the more effective for separation. It yields enrichments only for the metal, or metals, which form surface active compounds; whereas the second method gives enrichments for *all* positively charged ions in the solution.

Experimental

To test the possibility of applying the foam separation technique to metals in solution, some preliminary experiments with a single cation (strontium) in solution were carried out. Equipment and procedures employed were identical with those discussed in the following section except that strontium concentrations were determined chemically. The results are summarized in Figure 1, which is plotted on logarithm coordinates for convenience only; no special significance is attached to the apparent "straight-line" relationship shown.

Two foaming agents were tested. The first, *Bacto-Tryptose*, a commercial protein digest consisting of a mixture of peptides and amino acids, gave poor but positive results. The second, *Areskap 100*, a commercial surfactant, gave very promising results with enrichment ratios as high as 40 in the low concentration range (below 10^{-8} molar).

On the basis of these promising preliminary results, an experimental study of the removal of strontium from aqueous waste solutions by foam

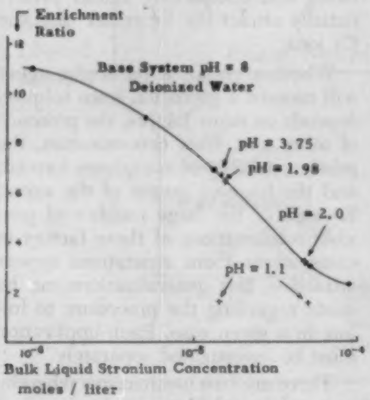


Figure 3. Effect of pH on strontium enrichment.

Table 1. Comparison of foaming agents for strontium enrichment.

Foaming Agent: Type	Example	$NaNO_3$ concentration — moles/liter: 0	0.01	0.1	1.0	5.3
		Sr^{++} Enrichment ratio				
Aromatic sulfonates	Areskap 100	5	3	*1.5-2	*1-1.2	1
Fatty acids	Sodium oleate			*6-21	*1.1-2	
Simple amino acids	Lauryl β-alanine	20		*1.8-2.8		*1.5-1.75
Polypeptides	Maypon K			2.6		
Amino polycarboxylic acids	Deriphat 160	30		7	2.1	1.2
Polyamino polycarboxylic acids	N-dodecyl benzyl diethylene triamine triacetic acid		2.1	4	5.8	6.4-8

NOTE: All data are for solutions 10^{-8} in strontium.
* Range in enrichment ratios due to variations in gas flow rate. High value in range corresponds to very low flow rate; low value to high flow rate. When no range is indicated, the value shown corresponds to an intermediate flow rate.

separation was undertaken.

The program may be divided into two more-or-less distinct aspects:

1. examination of the effects of **chemical** (i.e. pH, concentrations, etc.) and **operating** (i.e. temperature, gas flow rate, apparatus parameters, etc.) variables on enrichment values.
2. a survey of possible complexing and foaming agents to attain maximum enrichments.

Apparatus. The equipment used (Figure 2) is similar to that described by Kevorkian and Gaden (*2*). Foam chamber, column and collector are of glass, with vinyl tubing connections, while the gas sparger is a stainless steel spinnerette containing 100 holes of 50-micron diam.

Nitrogen at 15 lb./sq. in. gauge is filtered to remove dust and passed through a saturation chamber to prevent subsequent depletion of either foam or bulk liquid by solvent evaporation. Pressure and flow rate are measured and the gas stream introduced to the foaming column through the sparger. Foam is collected overhead, collapsed with a centrifugal foam breaker, and recycled to the column to obtain steady-state conditions. Samples of foam and bulk liquids are removed from taps provided in the collector and chamber, respectively.

Analysis. Since normal chemical analyses were unreliable at the very low concentrations involved, radiotracer techniques were employed. Strontium-89, diluted with inactive strontium carrier material, was used for all experimental runs. Foam and bulk liquid samples were evaporated to dryness and strontium concentrations determined by standard counting procedures (*4*).

One analytical complication arose because of the presence of yttrium-90 in the strontium-89 tracer material. Y^{90} is the radioactive daughter of Sr^{90}, also present in the Sr^{89} as an impurity. Analysis of the stock tracer material early in the program revealed that 3% of the counts came from the Y^{90} contaminant.

Since yttrium should exhibit enrichment ratios different from those for strontium, the presence of any Y^{90} in the Sr^{89} tracer used in the foaming experiments had some effect on measured strontium enrichments. (The analytical equipment interprets all counts, whether from Sr or Y, as due to Sr). This effect should be time-dependent since Y^{90} has a short half-life compared to Sr^{89}. To test this

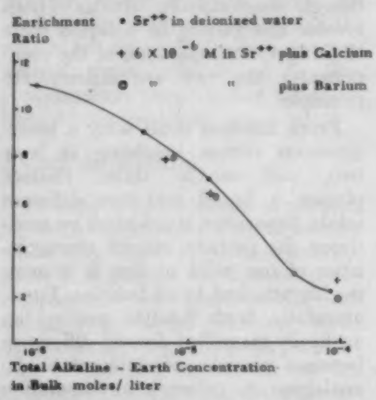
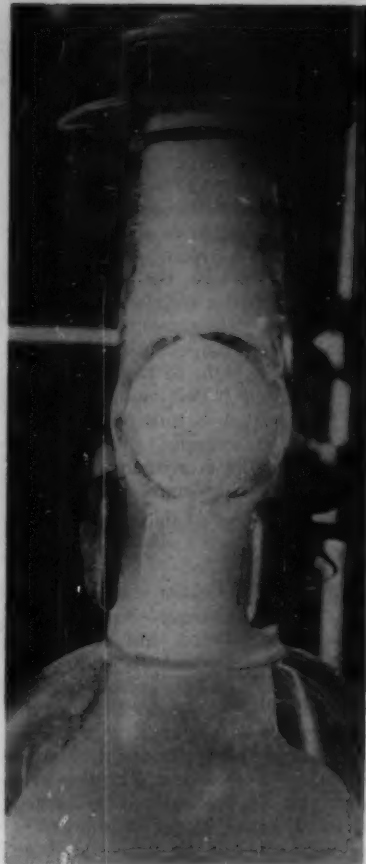


Figure 4. The effect of barium and calcium.



Detail view showing the foaming action in the column.

time effect, the enrichment ratios for six runs were determined from analyses made immediately after each run, and again ten days later. The results showed a distinct effect. Measured enrichments increased with time, indicating that yttrium is enriched less than strontium in this foaming operation. After about 15 days, equilibrium between Sr^{90} and its daughter Y^{90} was reached in both the foam and bulk liquid samples, and the correct Sr enrichment ratio could be measured. As a result all analyses were made 15 days after completion of a run.

Results

Attainment of steady state. Since the procedure used involved recirculation of streams (similar to conventional vapor-liquid equilibrium stills), it was necessary first to determine the time required to reach a steady state. On the assumption that the rate-controlling step was physical mixing in the foam collector, calculations indicated that the system should reach 99% of steady state after approximately 10 minutes. A series of experiments showed that the time actually varied between 5 and 20 minutes, depending upon flow rates and foam stability. Therefore, samples from all succeeding runs were taken after 20 minutes.

Reflux effect. During the experiments to determine the time required to reach steady state, certain peculiarities were noted. With relatively unstable foams (those which partially collapse in the foam column proper), steady state conditions were never attained, and large fluctuations in concentration, (hence in enrichment ratio) occurred. With stable foams, however, steady state was easily established and maintained. These observations demonstrated the influence of reflux in foam separation.

When the foam is unstable, its collapse within the foam column contributes "internal" reflux to the column. This reflux acts to increase enrichment and the effluent foam concentration fluctuates with the aberrations in foam stability. With a stable foam, collapse within the column does not occur and variations in enrichments due to reflux are absent. These results, although only qualitative, indicate promise for the deliberate use of external reflux to increase separations.

Strontium Separation. Since Areskap 100 (sodium *o*-hydroxy phenyl butyl benzene sulfonate) produced excellent enrichments for strontium in the preliminary experiments, it was used exclusively in the experiments reported below. To establish a *base system* against which subsequent data could be compared, enrichment ratios for strontium in deionized water were determined over the concentration range from 10^{-4} to 10^{-6} *M*. The standard Areskap 100 concentration was 1.6 gr./liter, giving a solution of pH 8.

The strontium enrichments were found to be substantially independent of pH over the range 2 to 8, Figure 3. However, when pH is reduced to 1, there is a marked drop in the enrichment value.

This effect can be explained as follows: In the range above pH 2, there is sufficient foaming agent present in the ionic form to completely complex all the strontium present. Below pH 2, the foaming agent exists mainly in the acid form and cannot complex a sufficient amount of Sr^{++} to give high enrichments. For foam separation to be successful in highly acid solutions, a foaming agent with a more favorable acid constant than Areskap 100 is needed.

Alkaline Earth Concentration. When strontium enrichment ratios are determined in solutions containing other Group II cations (Mg^{++}, Ca^{++}, Ba^{++}, etc.) lower values are obtained A plot of enrichment vs. total alkaline earth concentration, Figure 4, shows that this parameter, rather than strontium concentration alone, is the detemining one. This was anticipated because of the similarities among the alkaline earths. Normally, two or more surface-active agents in a solution do not act independently but compete with each other for positions at surfaces. When these surface-active components have similar properties (as the complexes of a particular foaming agent with the alkaline earths) their interactions are large—so large in this case that the solution scarcely differentiates between them.

Gas Flow Rate. Kevorkian and Gaden (2) have reported a decrease in enrichment ratio with increasing gas flow rate. To verify this conclusion, several runs were made at varying gas rates. The results, Figure 5, substantiated the previous work. An amplification of this was obtained from measurements of foam bulk density and enrichment ratio, when both are related to gas flow rate. In Figure 5, enrichment ratio appears to be some inverse function of foam density.

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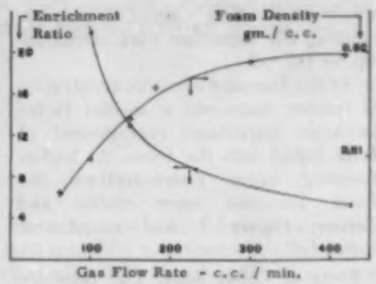

Figure 5. Effect of flow rate.

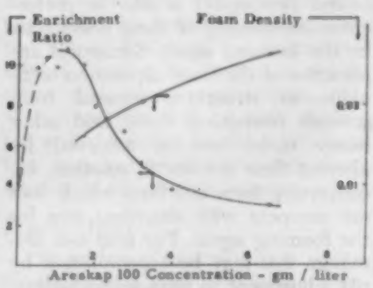

Figure 6. Effect of foaming agent concentration.

Foam fractionation

continued

Again, this effect is predictable from the general principles of foam separation, for bulk density is a measure of the amount of liquid "entrained" in the foam. Since separation by foaming is a surface effect, enrichments should be highest for a foam of high surface-to-volume ratio; a low-density foam. As gas flow increases, entrainment of bulk liquid (and foam density) increases and enrichment values fall accordingly.

Foaming Agent Concentration. Strontium enrichments have been found to be dependent on the concentration of foaming agent used, Figure 6. As foaming agent concentration is increased, there is an initial rapid increase in strontium enrichment ratio, followed by a rapid drop, and finally, a gradual decrease. This effect can be interpreted in the following manner. With no foaming agent present there should be no strontium enrichments, and an enrichment ratio of 1 is expected. As foaming agent is added, up to a concentration sufficient to complex all the strontium present, enrichment increases to its maximum value. Further addition of foaming agent creates competition for positions at the gas-liquid interface, between the excess foaming agent and the strontium-foaming agent complex, causing the strontium enrichment ratio to fall off.

As the foaming agent concentration is further increased a second factor becomes important, entrainment of bulk liquid into the foam. At higher foaming agent concentrations the foam becomes more stable and denser, Figure 6, and enrichment ratios fall.

Effects of Other Ions. The presence of heavier metal ions like Fe^{+++} and Al^{+++} reduces strontium enrichment, often causing precipitation of the foaming agent. This phenomenon (noted previously) is due to preferential complexing of these heavy ions by the foaming agent. Successful application of the foam separation technique to strontium removal from streams containing these and other heavy metal ions is achieved by altering their activity in solution, i.e. converting them to a form which does not compete with strontium ions for the foaming agent. For iron and aluminum this may be accomplished by pH adjustment to form ferric hydroxide and aluminate ions.

The effect of light alkali metals has been studied using sodium as the representative example. As anticipated, low sodium concentrations ($<10^{-2}M$) had no detectable effect on strontium enrichment. Since sodium ions are rather inactive complexers, their presence produces only a small indirect effect, by alteration of the solution's ionic strength. As sodium concentration is increased from $10^{-2}M$ to $5M$, strontium enrichment ratio falls to nearly unity.

An agent like Areskap 100 is not particularly selective for strontium so, when the Na to Sr concentration ratio is higher than 10^3 (the ratio for a 0.01 M $NaNo_3$ test solution) competition between Na^+ and Sr^{++} for the foaming agent favors sodium. In such a solution most of the strontium remains uncomplexed and cannot be enriched by foaming.

Selection of foaming agent

Successful application of foaming to strontium removal from high salt-concentration solutions requires a foaming agent with more strontium complexing-power than Areskap 100. An agent should be chosen such that the strontium equilibrium constant for complex formation divided by the sodium constant is greater than the sodium to strontium concentration ratio. This will eliminate interference due to competition between sodium and strontium.

Table 1 compares various foaming agents which have been tested. The results for Areskap 100 (typical of organic sulfonates) are poor, as anticipated above, because of their low-specificity for strontium.

The fatty acid group (typified by sodium oleate) was examined not for its complexing powers—which should not be much better than the sulfonates—but for its availability and low cost. Sodium oleate is superior to Areskap 100 in solutions up to 0.1 M in sodium concentration. At higher sodium concentrations the strontium enrichment falls off rapidly. Still it is important to note that a material as cheap as sodium oleate does yield excellent strontium enrichment in solutions up to 0.1 M in sodium.

The last four groups tested can be considered variations of a single class of agents—amino acids and their derivatives. The first of these, *simple amino acids*, possesses good complexing powers but poor surface activity. The second, *polypeptides*, has somewhat better surface properties, but lower complexing ability. The third, *amino polycarboxylic acids*, has both excellent surface activity and good complexing power. The last group, *poly-amino polycarboxylic acids*, is ideal for strontium separation by foaming; has extremely high chelating strength for strontium, relatively low attraction for sodium, and good surface-active properties.

For the first five types of agents tested, enrichment falls off as $NaNO_3$ concentration increases, indicating that each is limited in application by competition between sodium and strontium. However, the last type actually gives better enrichments as salt concentration increases, indicating that its strontium-complexing-power is sufficiently high, so that even in a near-saturated $NaNO_3$ solution, sodium competition is unimportant. For this specific example, the presence of sodium salts is actually beneficial in that it increases surface activity by salting out.

Summary

A novel application of the foam separation technique—removal of metals from solution—has been demonstrated and studied. As with other foam separations, best results should be obtained at low concentrations; in only rare cases will foaming of metals be a successful separation technique at high concentrations. This fact suggests that application will be limited to cases where traces of a metallic impurity are to be removed from solution, dilute solutions of a metal are to be concentrated, or traces of a metal are to be recovered from dilute solutions.

The effects of chemical and physical variables so far observed are in accord with generalizations previously established and indicate the importance of foam stability, foaming agent concentration, and liquid reflux. The most important factor in determining the success of a particular application of metals separation by foaming seems to be the proper choice of foaming-complexing agent.

LITERATURE CITED

1. Gorman, A. E., *Ind. Eng. Chem.*, **45**, 2672 (1953)
2. Kevorkian V., and E. L. Gaden, Jr. *A.I.Ch.E. J.* (*in press*)
3. Schnepf, R. W., and E. L. Gaden, Jr. *J. Biochem. and Microbiological Tech. and Eng.* (*in press*)
4. Zumwalt, L. R. "Handbook of Radio Chem. Anal.", U. S., Dept. of Comm., Wash. (1953)

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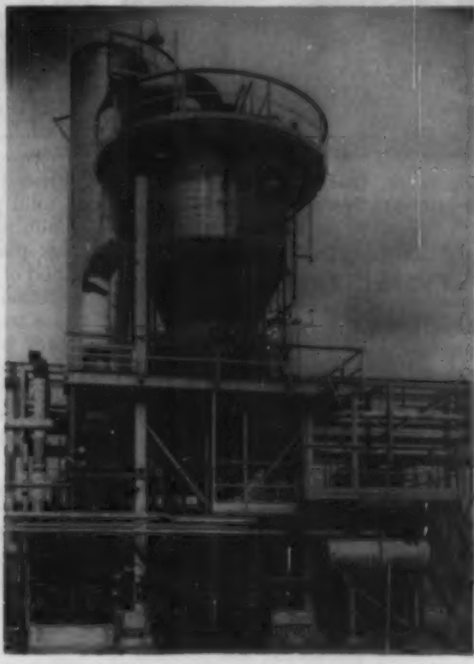
Presented at A.I.Ch.E. Salt Lake City meeting under the title "Foam Fractionation of Metals, Separation of Strontium from Aqueous Solution."

Solids recovery by Crystallization



A Struthers Wells evaporator-crystallizer used to remove sodium chloride from an organic process operation.

Hans Svanoe
Struthers Wells Corporation
Warren, Pennsylvania

An outstanding characteristic of the crystallization process is that, in many cases, it is the only way to obtain high-purity materials from impure solutions.

Crystalline chemicals are produced under widely different operating conditions. The product may have to be crystallized at a temperature of several hundred degrees Centigrade, or way below zero. At operating conditions, the viscosity of the solution may be equivalent to water, or several thousand times greater. This means that the designer of crystallizer equipment must be prepared to evaluate the relative importance of the chemical and physical characteristics to attain the objective at the lowest cost. Some of the factors considered in the design of equipment to produce crystalline materials from solutions will be discussed in this paper.

The raw materials used in producing crystals almost invariably contain other elements or compounds, which often means that extended investigations must be undertaken before even preliminary specifications can be formulated for the crystallization step.

Solubility relationships must be determined for the entire operating range, either by literature search, original laboratory work, or both (*1*). In addition, heat and material balances must be prepared to determine the general flowsheet, the nature and size of heating or cooling surfaces, steam and water requirements, etc. The proper conduct of such studies has a vital bearing on the crystallization step regarding operating characteristics and overall economics.

Nucleation

The process of crystallization, or the formation of a new solid phase from a supersaturated solution, can be con-

continued

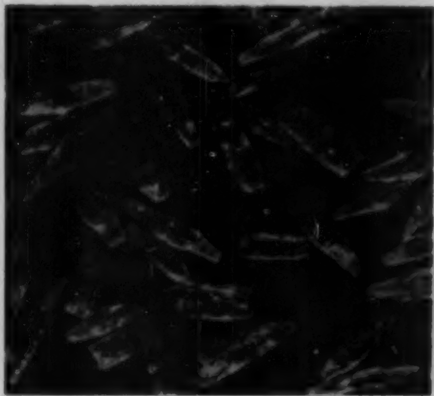


Figure 3. $(NH_4)_2SO_4$ at 0.5% supersaturation. (Magnification 4.2X.)

. . .With increasing radius of the particle, these free energies will reach a maximum.

Crystallization

continued

sidered in two steps; the formation of nuclei, and their growth to the desired dimensions. In both steps, the *degree of supersaturation* of the solute is the controlling factor.

Many theoretical studies have been published on homogeneous nucleation in solutions (2) (self-nucleation process.) While these studies do not apply directly to a continuous crystallization process where nucleation and crystal growth occur, homogeneous nucleation is of interest in advancing our understanding of the crystallization process. An excellent summary of homogeneous nucleation was presented by C. Robert Landgren (3) at the 1955 Houston National Meeting of A.I.Ch.E.

A two-phase system consisting of a saturated solution of a chemical and its solid phase is considered to be in equilibrium if no observable change takes place, even after an indefinite period of time. However, a metastable condition can be established if in phase transformation a maximum free energy is attained. This (as Landgren points out) is the case in the formation of nuclei.

The free energy of formation of the nuclei can be considered to be composed of two parts:

1. The free energy change due to the difference in free energy of bulk quantities of the two phases. This quantity will *decrease* with the cube of the radius of the nucleus.
2. The free energy of the surface formed. This will *increase* directly with the surface area, or as the square of the radius of the nucleus.

With increasing radius of the particle, these free energies will reach a maximum, representing the size of nucleus required for spontaneous growth from the supersaturated system. However, this represents a metastable condition, since the addition of particles larger than the maximum would result in growth with a decrease in free energy. At a given supersaturation in the system, a certain-sized particle is therefore required before crystal growth can proceed. As the supersaturation is increased, this maximum is reached at a smaller radius of the nucleus. Therefore, the higher the supersaturation, the smaller the nucleus at which the free energy of formation is a maximum, and growth can proceed.

Metastable supersaturation

Ostwald was apparently the first to

Figure 2. $(NH_4)_2SO_4$ at 7 percent supersaturation. (Magnification 4.2X.)

use the terms "metastable" and "unstable" (labile) supersaturation. These terms have been used extensively but with vague definitions and a short review may therefore be of value. An abstract of Ostwald's original publication is given by La Mer (*4*):

"Among supersaturated solutions there are some which, if nuclei are excluded, will apparently last indefinitely under certain conditions, without ever spontaneously forming a solid phase. Such solutions will be called **metastable.**

"There are other supersaturated solutions in which, even if nuclei are excluded, the solid phase will spontaneously appear after a limited time. Such solutions are called **unstable.**

"Metastable solutions always have a lower concentration than unstable solutions of the same substances. Through increase in concentration, therefore, a metastable solution can be converted to the unstable condition. The concentration at which this transition occurs may be called the **metastable limit.**"

The occurrence of metastable and labile regions of supersaturation was investigated further by Miers (*5*) who determined these regions in quiet solutions, and without the presence of the solid phase. While the metastable supersaturation determined in this way has significance, it must be used with caution as the so-called *allowable degree of supersaturation* in continuous operation is only a fraction of the Miers value, due to the presence of small crystals, or nuclei, in the zone of supersaturation.

Nucleation in a dynamic system

In a continuous crystallization process the number of nuclei formed and retained per unit time, should be equal to the number of crystals withdrawn from the crystallizer as product, per unit time.

In such a process, where some means are used to keep the growing crystals suspended in a supersaturated solution, very small crystals will always be present in the zone where supersaturation is being produced. These crystals will control the degree of supersaturation that can be maintained in the system, to the extent that the so-called allowable degree of supersaturation, is only a fraction of the measured metastable supersaturation in unseeded solutions.

While the determination of the operational degree of supersaturation (allowable supersaturation in the presence of small crystals) for industrial solutions would be desirable, very little work in this field has been reported.

Webre (*6*) has defined different regions for sucrose solutions in these terms:

1. "Existing crystals grow in the **metastable** region, but no new ones form. This zone persists to a supersaturation of about 1.2 (the ratio of the actual concentration to the solubility, in terms of units of sugar per unit of water.)
2. "Beyond the metastable range [lies] the **intermediate** (or period of false grain) in which not only do existing crystals grow, but new ones form. This zone extends from a supersaturation of about 1.2 to 1.3.
3. "Above this latter value is the **labile zone,** in which crystals form spontaneously without the presence of others."

Expressing sucrose supersaturation in percent of solute present above the equilibrium value at the saturation point, the ratio 1.2 is equivalent to 20% and 1.3 to 30% supersaturation, respectively. For most inorganic solutions, Webre's metastable range is considerably lower; in the order of 0.5 to 1.0%. This concept of **three zones of supersaturation** is most useful in the crystallization process. The numerical degree of supersaturation for these zones can seldom be established with accuracy, as the boundary line is not sharp.

A series of experiments by Ting and McCabe (*7*), were conducted with bench scale equipment in continuously cooled, stirred, and seeded solutions of $MgSO_4$, which included two *points of observation*. Only the first point is considered here (where new nuclei are first observed) as this is the more important in a continuous crystallization process.

Seed crystals of known weight and size were introduced at the saturation point, and crystallization was started by cooling with mineral oil. The temperature difference between circulating oil and crystallizer was about 2° C. With 0.1% seed crystals present in the solution and at a supersaturation of 0.7 to 2%, nuclei appeared after 4-15 min.

For contrast, Ting and McCabe made runs without seeding, using a cooling rate of 0.24° C/hr. In these cases no nuclei appeared, even at a superaturation of 15% or higher, and a total cooling time of several hours. The runs demonstrate the pronounced effect on the nucleation rate of the presence of solute crystals in the supersaturated solution.

Van Hook and Bruno (*8*) report that suspended foreign particles of ordinary refined sugar seem to have no appreciable effect upon the nucleation time. However, Turnbull and Vonnegut (*9*) point out that compounds acting as nucleation catalysts (reducing the nucleation time) have structures with a symmetry and lattice spacing similar to that of the forming crystal.

Unsharp phase transitions

Many crystalline solids can exist in

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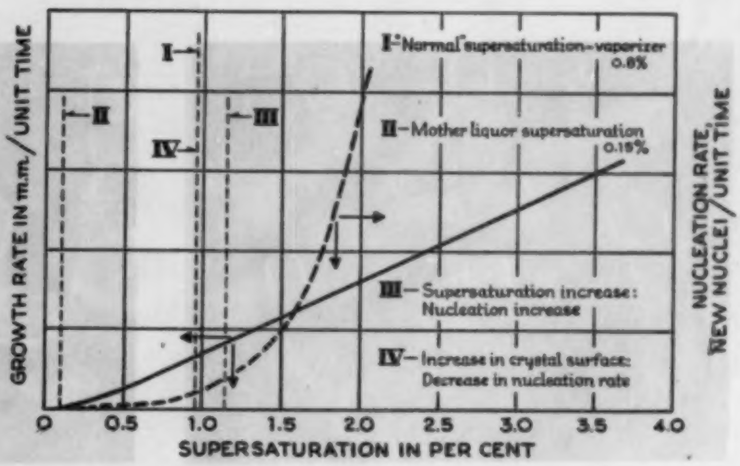

Figure 1. A nucleation growth chart.

. . . the behavior of the different solid phases should be studied under process conditions to obtain the desired crystal form.

continued

different crystal structures, or as hydrates with varying amounts of water of crystallization. Such solids can appear *outside* the concentration-temperature range of their stable phase.

An early observation of this phenomenon was reported by Lecocq de Boisbaudron in 1866 for the sulfates of bivalent metals like Cu and Mg; that different hydrates could be crystallized from the same supersaturated solution by seeding with the specific crystalline form. Without seeding, the most stable phase did not always separate (*6*).

J. D'Ans and P. Höfer (*10*) investigated the transition rate of the phases in the system: $CaSO_4-H_3PO_4-H_2O$ in different acid concentrations at 25 and 83° C. The rate varied from a few minutes to several days, and even longer. In an example by Gale (*11*), where the triple salt *hanksite* is the stable solid at a certain process step in treating Searles Lake brine, even in the presence of the proper solid phase, supersaturated solutions of hanksite require weeks and even months to reach equilibrium. Thus, the existence of hanksite is neglected in the Trona evaporation of brine.

The first step in the crystallization of pigments (*12*), is obtaining the desired chemical compound. To attain the proper purity this compound must be crystallized. The particle size, crystal habit, and size distribution must be controlled, and the solid phase must be in the most desirable crystal structure, which may not be the equilibrium phase. In fact, crystalline solids frequently appear outside the equilibrium field. When encountered in a crystallization step, the behavior of the different solid phases should be studied under process conditions to obtain the desired form.

Crystal quality

Crystal quality can be specified by the following:

1. Uniformity of the produced crystals
2. Crystal purity
3. Crystal hardness

Uniformity of produced crystals

The desired sizes and size-distribution of the crystalline chemicals vary greatly; from + 10-mesh or larger, to − 100-mesh, and with a wide weight distribution within these sizes. If the crystalline solid is a chemical intermediate, the important requirement of the crystals will be economy in handling after the crystallization process for ease in filtering and washing operations.

The published results and analysis of size distribution are not extensive and it is of interest to review a few recent papers.

Saeman (*13*) has discussed the removal of excess nuclei from mixed, circulating suspensions in a vacuum crystallizer. His analysis deals with cases where the nucleation rate is excessive; that is, more nuclei are continuously formed than are required for the desired size. He concluded that under certain conditions, the cumulative size distribution in the circulating suspension varies as the fourth power of the crystal size; also that the important factor in size control is the segregation-time of the smaller crystals in the *fines*-removal system. Furthermore, if proper conditions of crystal growth are maintained in the crystallizer, the size-distribution functions indicate that in the majority of cases, the smaller crystal sizes are unimportant on a weight basis. This means that in a well-designed unit, product classification is required only where specifications call for a very uniform product.

Saeman does not consider crystal breakage in his analysis. It can be pointed out, however, that the influence of crystal breakage in a well-designed hydraulic system is negligible.

Robinson and Roberts (*14*) discussed crystal growth and distribution in a single unit, and in a cascade of units, under certain specified conditions. Like Saeman, they assumed that the linear ratio of growth is proportional to the supersaturation of the solution in contact with the crystals; and further they assumed: that a unit number of nuclei enter the system per unit time, perfect mixing, and that an equilibrium stage has been reached in the system. They compared the theoretical analysis with actual results from a single-unit operation (vacuum crystallizer producing ammonium sulfate), with excellent agreement, Table 1.

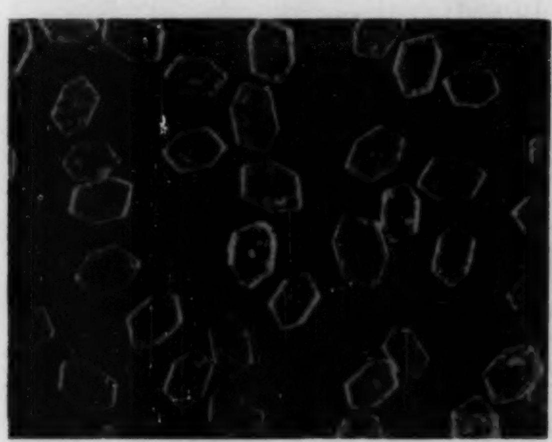

Figure 4. $2K_2CO_3 \cdot 3H_2O$—1.5 KCl in mother liquor. (Magnification 1.8X.)

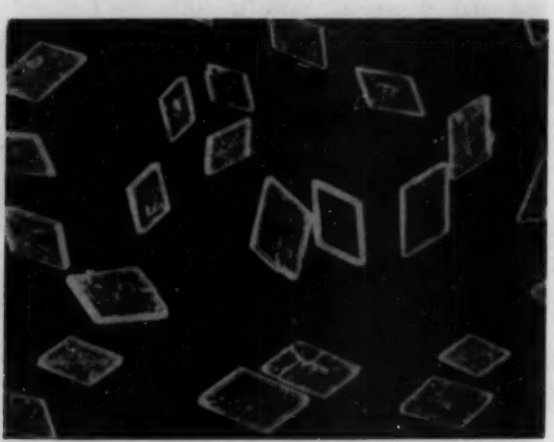

Figure 5. $2K_2CO_3 \cdot 3H_2O$—no KCl in mother liquor. (Magnification 1.9X.)

TABLE 1
Comparison of Actual and Theoretical Screen Analyses

Screen Size (Tyler)	+14	+20	+28	+35	+48
Cum. % Wt.					
Actual	60.4	82.5	93.6	97.4	98.7
Theoretical	60.9	80.7	92.1	97.2	99.1

Robinson and Roberts also analyzed calculated values for crystal size distribution when a number of crystallizer units are operated either in series or parallel. Under the assumed conditions they noted that for equivalent crystal quality, considering size and size-distribution, the productive capacity is less than half with series operation. They also indicate a narrow range of the allowable degree of supersaturation for producing relatively large ammonium sulfate crystals.

This can be illustrated by a nucleation-growth chart, modified after Perry (*15*), Figure 1.

It is assumed that the crystallizer operates at an average, or normal, supersaturation in the vaporizer of 0.8%. There is a close inter-relationship between supersaturation, crystal surface, amount of crystals in suspension, and size of crystals produced. This "cycling" can be very regular with the peak in crystal size appearing hours apart. The overall result is that the crystal size can vary between certain limits for the maximum and minimum available crystal surface.

Purity of the crystals

In many cases, industrial chemicals are raw materials used in other processes and should have a consistent purity, therefore a review of possible sources of impurities is of interest. Where solid solutions are formed or where several solids crystallize as separate phases at the same time, the problem must be treated accordingly.

Impurities from adhering mother liquor. In a centrifuge, or filter, where the purpose is to reduce the amount of mother liquor adhering to the crystal surface, the efficiency of the separation process depends to a large extent upon the uniformity of the crystals and the relative amount of crystal surface per unit weight of crystalline material. Provided the viscosity of the liquid portion is not too high, and the product is free of fines, the mother liquor content can be reduced to less than 2% (or in water solution the moisture content to less than 1%). Assuming that the mother liquor contains water (as a solute) and impurity in the ratio of 15 to 1, by reducing the moisture content from adhering mother liquor after the centrifuge to 1%, the percentage of impurity from adhering mother liquor will then be 1/15th of 1% or close to 0.07%. These surface impurities can be reduced further by washing the crystals on the centrifuge with a solvent.

Impurities attached to the crystal by adsorption. The amount of impurity that will attach itself to the crystal can follow the general equation for the adsorption isotherm. Some results from organic crystals grown at low degree of supersaturation in a continuous unit from a water solution are of interest (*16*).

Comparing the solute impurity ratio on a weight basis in crystals and mother liquor, the following results were obtained:

	Mother Liquor		Crystal
Solute: Impurity	4:1	→	400:1
Solute: Impurity	14:1	→	3000:1

In general, the amount of impurities that may be due to adsorption on a crystal surface can't be correlated on a theoretical basis. As stated by Langmuir and quoted by Buckley (*5*):

". . . it is apparent that the phenomena of adsorption cover nearly the whole of the chemistry and physics of surface action. The complexity and variety of processes involved in adsorption are thus about as great as those in physical and chemical changes of state in homogeneous media. In the study of adsorption we should therefore expect to find many different types of adsorption phenomena and, in general, unless great care is taken to simplify the experimental conditions, we should expect the observed phenomena to be of the utmost complexity."

Impurities by mother liquor inclusion in the growing crystal. The lower the supersaturation, the more regularly do crystals grow. Higher ranges of supersaturation induce flawed growth and allow mother liquor to be included between layers of crystallites, as well as between crystal aggregates. If crystal quality is affected to a serious degree from this source, the supersaturation and growth rate have to be reduced.

Impurities in the crystal lattice. Specific information regarding the amount of impurities in the crystal lattice in industrial crystalline products is not very extensive. For products of technical grade this impurity source is not as evident as the other cases given here. Recent research in solid state physics has given us much important information about the effect of very small impurities within the crystal lattice to change some physical characteristics. This will have im-

continued

Figure 6. $CuSO_4 \cdot 5H_2O$—low acidity. (Magnification 4.5X.)

Figure 7. $CuSO_4 \cdot 5H_2O$—mother liquor 6% H_2SO_4. (Magnification 6.9X.)

Crystallization

continued

portant future applications in preparing crystals for specific applications.

Change in crystal habit

The faces on a crystalline solid develop at different rates due to different external conditions of growth. The form which the crystal assumes due to the relative sizes of its faces is called the **crystal habit.**

The handling qualities and appearance of a solid can, at times, be improved by changing its crystal habit. The amount of chemical to be added to obtain a definite change in crystal habit is variable; however, some general observations may be of interest.

Effect of supersaturation. Different faces of a crystal can grow at different rates at the same degree of supersaturation. The growing rates on the faces can also vary in some different degree with a change in supersaturation, Figures 2 and 3.

Effect of impurities. As most industrial solutions contain impurities, it is often advantageous to maintain the impurities, at concentrations to produce a crystal habit resulting in a product with specific properties, Figures 4 and 5.

When inorganic impurities affect the habit, the concentration of these impurities in the mother liquor can be less than 1%, and also considerably higher, before a decided difference is observed in crystal habit. Certain sulfates are produced on a commercial scale from acidic solutions. As a rule, better crystal habit is obtained by crystallizing at controlled and low acidity, Figures 6 and 7.

For fertilizer chemicals like ammonium sulfate, and potassium chloride, the object is to produce essentially non-caking materials. Crystal habit in this case is quite significant, Figures 8 and 9. A cubical crystal like potassium chloride is some-what unique in producing a spherical crystal, which is beneficial for a non-caking fertilizer material, Figure 10. According to Stranski (*17*), the spherical growth is caused by solution-concentration gradients surrounding the crystals being eliminated during the growth.

Crystallizing from different solvents. Organic compounds are often soluble in a variety of solvents and form crystal habits characteristic of certain solvents or combinations of solvents. Wells (*18*) reports that pentaerythritol crystallizes from a water solution in the form of a tetragonal bipyramid; changing the solvent to acetone, tetragonal plates result. Aspirin crystallizes as long needles from water solution, and as plates from certain solvents (*5*).

Effect of organic chemicals like surface active agents. Surfactants can change crystal habit markedly, and in concentrations of less than 100 ppm. This is apparently due to the ability of the chemical to concentrate at the surface of the crystalline solid and arrange itself in a specific manner. Since surface active agents are compounds with definite structures, it should be possible to change surface conditions to obtain a "tailor-made" habit. According to Knacke and Stranski (*19*), the surface energy of certain planes is reduced by adsorption of foreign materials so that a new crystal equilibrium or habit results.

Aggregates and twins. Solid state studies have focused attention on the deviations of crystals from perfect structures. Theoretical calculations indicate that to obtain crystal growth, the degree of supersaturation must be considerably higher than used in industrial practice.

The dislocation concept has confirmed that imperfections in crystals make growth possible at low degrees of supersaturation. The motion of dislocation explains the formation of some twin crystals (*20*). During twinning, a displacement occurs on crystallographic planes and following this, the deformed part of the crystal is grown to a mirror image of the mother crystal. Certain crystals show this characteristic rather frequently, and some invariably.

Aggregates or twins are not desirable in a commercial product. They change the bulk density of the material and in addition, the structure of twin crystals and aggregates is inferior to the host crystal, causing dust and segregation in handling.

In industrial processes, aggregates can occur at a relatively high degree of supersaturation; however, when a stable suspension has been established and supersaturation has been reduced, the aggregates may (at times) disappear, Figures 11 and 12.

Crystal hardness

The term "hardness" is used in mineralogy to indicate the mineral's resistance to abrasion or scratching. A crystal grown under controlled conditions should have a consistent hardness. However, in an industrial plant crystals are grown under a great variety of conditions due to difference in raw materials, process, and design elements.

As mentioned before, a crystal grown at high supersaturation will have a high rate of growth; however, the crystal quality may be poor, Fig-

Figure 8. $(NH_4)_2SO_4$—organic additive. (Magnification 2.8X.)

Figure 9. $(NH_4)_2SO_4$, synthetic, pH 3.0 and organic impurity. (Magnification 2.6X.)

ure 2. These crystals were grown at very high supersaturation, the structure is weak and the product is not commercially suitable.

Additives are sometimes used for chemicals like ammonium sulfate to stabilize or increase the allowable degree of supersaturation. In such cases, the crystal hardness will suffer slightly due to the increase in growth rate.

High supersaturation can cause crystals to form into aggregates which often break up in centrifuging and drying operations, resulting in dust losses, caking problems, and change in the bulk weight of the material. In some cases, formation of crystal aggregates can be prevented by certain additives.

It is an advantage therefore to produce uniform supersaturation in industrial units. The cooler or evaporator where the supersaturation is produced should be designed with this in mind, to hinder solution bypass, and thereby prevent liquor side streams of high supersaturation.

Remaining supersaturation in mother liquor. In most inorganic processes the crystallization end-point (batch or continuous operation) is close to the equilibrium point, and the yield can be calculated from the solubility curve. However, for some organic compounds, the remaining supersaturation can be 10 to 20%, or even higher, and this must be determined to calculate the yield of crystalline solid. High, remaining supersaturation is to be avoided where liquor is passed through a number of crystallizer units in series. When a supersaturated solution enters the next unit and is mixed with mother liquor that is only partly **desupersaturated,** the result is almost invariably excessive formation of nuclei.

In such cases the liquor should be desupersaturated to the extent where excessive formation of nuclei can be avoided. This may be accomplished by providing an effective solid-liquid contact in the crystallizer units, and ample crystal surface available for desupersaturation.

A uniform and vigorous solid-liquid contact must be established throughout the system to obtain maximum efficiency per unit volume of equipment. This is one of the important elements in crystallizer design, particularly for large equipment. This is more evident in equipment where a heavy crystal slurry must be suspended or circulated through a large cross-sectional area. Depending on the physical properties of the system, this can be accomplished by a classified,

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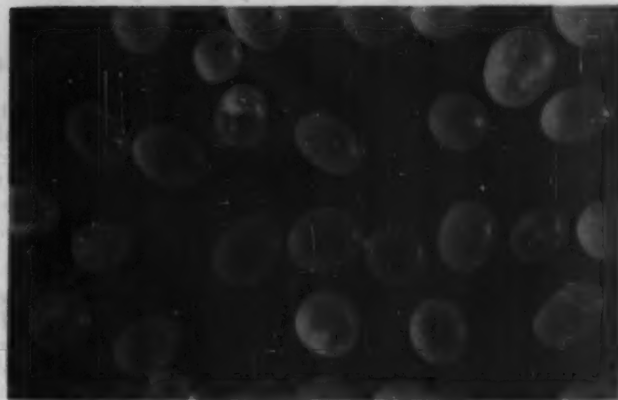

Figure 10. KCl solution saturated with NaCl. (Magnification 3.0X.)

Figure 11. $Na_2CO_3.H_2O$ at high supersaturation. (Magnification 4.2X.)

Figure 12. $Na_2CO_3.H_2O$—supersaturation 1% maximum. (Magnification 6.0X.)

Crystallization

continued

fluidized, or circulating suspension (*15*).

Rate of crystal growth and temperature. The rate of crystal growth at different temperatures depends, in some measure, on the solubility curve. When solubility increases with temperature, the allowable supersaturation and rate of growth will, as a rule, increase with increase in temperature.

The published information on rate of growth at the *same* percent supersaturation and different temperatures is meager. Some references in this respect are illuminating in illustrating the marked effect of temperature change.

Buckley (*21*) observed the growth rate of ethylene diamine *d*-tartrate. At a supersaturation of 0.5% and temperature of 42° C., the time to grow a 1-mm. crystal was almost 11 hours. Repeating the experiment at 0.5% supersaturation and 52° C., the growth rate increased nearly 30%.

Growing NaCl crystals at a constant supersaturation of 0.38% (*16*) and varying temperatures, the following results were obtained:

At 40° C., a 2.6-mm. crystal was obtained in 2.6 hr.; at 50° C., the growing rate increased nearly 25%.

Pilot plant

As noted, the allowable degree of supersaturation for many chemicals is 1% or less. As this is influenced by small deviations in composition of the mother liquor and the chemical and physical characteristics of the system, it is often advisable to experiment to collect the information required for design specifications.

The cost of pilot plant work can vary greatly; depending on the composition of raw materials, size of the project, whether done at a laboratory made available by the equipment designer, or at a more complete set-up in the field—where operation can be conducted for months to establish the most economical operating conditions to secure high crystal quality, filterability, non-caking material, etc.

When operating a pilot crystallizer, it is hardly possible to maintain magma consistency, temperatures, liquor concentrations, etc. as uniformly as in a large unit, where process variables can be maintained within narrow limits. A large unit can therefore operate at higher allowable supersaturation; that is, with higher capacity per unit volume. The usefulness of the results obtained in pilot plant work increases with the size of the equipment. Thus the effect of additives on the crystal habit can be fully realized only in large equipment.

Instrumentation

To obtain crystals of specific size, purity, and habit, it is essential to maintain uniform conditions in the crystallization system. This can be accomplished by proper control. The most important items to maintain within specified limits are uniform degree of supersaturation, and total crystal surface available for desupersaturation.

For some organic chemicals, like sugar, supersaturation of 20 to 30% can be recorded and controlled by automatic means. For inorganic solutions, the degree of maximum supersaturation during growth is usually less than 1%. This might be recorded with pure solutions; however, with industrial solutions a slight change in operating conditions can blanket an instrument reading to make it difficult to obtain accurate results. The supersaturation can be controlled by maintaining a certain quantity, as well as size-distribution, of crystals in the cycle. This can be recorded by some standard instruments for continuous density measurement. This procedure can be adopted independently of how the supersaturation is produced. It can be used in units where supersaturation is produced by liquid-cooling, vacuum-cooling, or evaporation.

Other process items like temperature, pressure, liquor levels, etc. can be recorded and controlled by well-established industrial practice.

Crystallization process cost

Cost of crystallizer equipment, for estimating purposes, can (at times) be obtained by comparison with cost figures from similar operations, or estimates can be obtained from equipment fabricators. Such figures are often required to compare crystallization with recovery of the chemical by some other unit operation such as spray drying or distillation. However, regarding the cost of the crystallization process, it must be borne in mind that additional process steps are required beyond the crystallizer, before the material can be used for further processing or be sold as a finished product.

Such process steps are usually the following: in the crystallizer the crystals are obtained suspended in mother liquor; crystals and mother liquor must be separated in a centrifuge or filter, and sometimes adhering mother liquor is removed by washing with a small quantity of solute, if required for purity; re-crystallization may also be necessary to obtain the required crystal purity, the remaining mother liquor is removed in a dryer to a specified moisture content; finally, the crystals are packed in special containers or stored in bulk.

These process steps are affected by required crystal uniformity and size. When handling a *uniform* material on a continuously-operated centrifuge, the capacity of the unit is increased and the moisture content is greatly reduced, as compared with unevenly-sized material. A low moisture content after the centrifuge, will also reduce the cost of the drying operation. In addition, the bulk weight can be maintained to fit customer requirements.

To obtain a reliable evaluation of total cost, these process steps must be included in the estimate. The investigation of these items are, as a rule, an important part of the pilot plant program.

As the requirements regarding crystal quality are steadily becoming more exacting, the chemical engineer should carefully consider all these steps in order to produce high quality chemicals at the highest efficiency and lowest cost.

LITERATURE CITED

1. D'Ans, J., "Die Lösungsgleichgewichte der Systeme der Salze ozeanischer Salzablagerungen," p. 1, (1933).
2. "Nucleation Phenomena," *Ind. Eng. Chem.* 44, 1269 (1952).
3. Landgren, R. C., Bell Tel. Labs., Murray Hill, N. J., private communication.
4. La Mer, V. K., *Ind. Eng. Chem.*, 44, 1270 (1952).
5. Buckley, H. E., "Crystal Growth," John Wiley & Sons, pp. 7, 341, 449 (1951).
6. Webre, A. L., in Spencer Meade's "Cane Sugar Handbook," John Wiley & Sons (1945).
7. Ting, H. H. and W. L. McCabe, *Ind. Eng. Chem.*, *26*, 1201 (1934).
8. Van Hook, A., and A. J. Bruno, Discussions of Faraday Soc., *5*, 114 (1949).
9. Turnbull, D., and B. Vonnegut, "Nucleation Catalysts," *Ind. Eng. Chem.*, 44, 1292 (1952).
10. D'Ans, J. and P. Höfer, *Angew Chem.* *50*, 101 (1937).
11. Gale, W. A., *Ind. Eng. Chem.*, *30*, 867 (1938).
12. *Ind. Eng. Chem.*, *47*, (Aug. 1955).
13. Saeman, W. C., *A.I.Ch.E. J.*, *2*, 107 (1956).
14. Robinson, J. N., and J. E. Roberts, *Can. J. Ch. E.*, p. 105 (Oct. 1957).
15. Perry, J. H., ed., "Chemical Engineers' Handbook," 3 ed., pp. 1061, 1068 McGraw-Hill Book Co., Inc., N. Y. (1950).
16. Private communication.
17. Finch, G. I., *J. Sci. Ind.*, Res. Vol. *16A* (Aug. 1957).
18. Wells, A. F., Discussions of Faraday Soc., *5*, p. 199 (1949).
19. Knacke, Von O., and Stranski, *Zeitschrift für Elektrochemie*, p. 816 (1956).
20. Kittel, C., "Solid State Physics," John Wiley & Sons, p. 589 (1956).
21. Booth, A. H., and H. E. Buckley, "*Nature*," p. 867 (1952).

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Pilot plant production *synthetic quartz*

Quartz crystal is an essential component in long distance communication equipment where its piezoelectric properties are used in filters, oscillators and other devices. Other piezoelectric crystals are less satisfactory than quartz because of such problems as water solubility, large temperature coefficients of frequency, and low Q (*1*). Although silicon (mainly in the form of the dioxide, and generally as small quartz crystallites) comprises approximately one third of the earth's crust, natural quartz crystals of size and quality suitable for use in apparatus employing their piezoelectric properties, are found principally in Brazil. Large deposits of low quality quartz are found in the United States and Madagascar, but the Western Electric Co. and other manufacturers of oscillators and filters in the United States are entirely dependent on the Brazilian supply. The Brazilian deposits are scattered over wide areas, mostly in the interior, and there is no large organized mining operation. Individuals, as free agents, either dig the crystals from the ground, or find them in the beds of rivers. Recently the supply has become quite unstable owing to the apparent scarcity of larger stones. The instability of the supply, combined with its vulnerability in the event of war was vividly demonstrated during World War II, when it was necessary to develop and use other piezoelectric materials as quartz substitutes; notably ethylene diamine tartrate.

Interest in the production of synthetic quartz was evidenced as long ago as 1851 by de Senarmont (*2*). However, no marked progress toward the preparation of crystals of reasonable size was made until the work of G. Spezia (*3*), in 1905, who used a technique, since called *hydrothermal crystallization*. Hydrothermal crystallization may be defined as the use of an aqueous solvent under high temperature and high pressure, to increase the solubility of an ordinarily difficultly soluble material to a point where it can be crystallized on a seed crystal at an appreciable rate without excessive self-nucleation. Spezia's process was too slow to be commercially attractive. During World War II, R. Nacken (*4*), in Germany, conducted research on the crystallization of quartz, which was brought to the attention of investigators in other countries in 1945. Although the Nacken process was shown to be impractical (*5*), its investigation led researchers to fruitful means of achieving quartz growth. Notable contributions were made by Hale (*6*), Brown (*7*), Walker and Buehler (*8*), Kohman (*9*), and others. This article describes the transfer of the hydrothermal quartz-crystallization process, as devised in Bell Telephone Laboratories (*8, 9, 10*), to pilot-plant production in the Western Electric Co.

Laboratory process

Recent developments in the laboratory process upon which the calculations for pilot-plant production were based, together with the results of a kinetic study of the system used for quartz growth, are reported in the literature (*10*) so that only a brief summary will be given here. The system studied in the laboratory was $H_2O-NaOH-SiO_2$ at relatively low $NaOH$—concentration, in a pressure-temperature range where quartz was the stable solid phase. The phase-equilibria studies of Morey (*11*), Kennedy (*12*), and others were guides, but it was necessary to investigate the solubility of quartz over the low-concentration region of interest, since data published were for higher $NaOH$-concentrations.

continued

Growth was achieved by placing small particles of nutrient quartz in the bottom of a cylindrical autoclave and suspending seed crystals of the desired orientation in the top, or growth region. The vessel was filled to a high fraction of its free volume (75 to 87%) with a 0.50 to 1.50 *N* NaOH solution and heated on the bottom. The basic NaOH was used to aid in increasing the solubility of *amphoteric* SiO_2. The vessel was heated in such a way that axial and radial heat losses caused the growth region to be cooler than the nutrient region. At temperatures above about 300°C (572°F), the vessel filled completely with a fluid phase, and at a temperature difference from nutrient to growth zones of from 20 to 70°C (36 to 126°F), the supersaturation was high enough to cause quite rapid growth.

The vessels used in the laboratory were of the welded closure design described by Walker (*8*). Their internal dimensions were 1 in. diam. by 1 ft. length. Heat was supplied by a hot plate controlled by a Leeds Northrup Micromax Controller. The vessel was placed on a hot plate and surrounded by vermiculite insulation. Brazilian quartz seed plates, of known dimensions and of the desired orientation, were placed in the growth region of the vessel, and small particles of Brazilian quartz were placed in the nutrient region. The nutrient and growth regions were separated by a perforated metal disc or baffle. It was found in the laboratory that the baffle aided in decreasing growth-rate differences between crystals in the growth region. The autoclave was filled to the desired percent of its free volume with NaOH of the desired concentration, and maintained under predetermined temperature conditions for a period sufficient to establish the growth rate. Internal temperatures of the laboratory vessels were determined by probing vessels of similar geometry with sheathed thermocouples (*10*).

At the conclusion of a run, the crystals were removed, and the growth rate was calculated from their increase in dimensions. Rates were reported as the increase in thickness of a plate, in thousandths-of-an-inch (mil) per day, in a direction normal to the face studied. The faces investigated in the laboratory were the basal plane, (0001), the z-minor rhombohedral (01$\bar{1}$1), the major rhombohedral (10$\bar{1}$1), and the prism (10$\bar{1}$0).

It was found from laboratory studies, that the parameters of principal importance were: the orientation of the seed the temperature of the growth region, the temperature difference between the nutrient and growth regions, and the percent fill. The concentration of NaOH, and the percent cross-section of the area left open by the baffle were also found to be of importance. Most of these parameters were studied by making series of runs in which one parameter was varied while the others were held constant.

It was found that the *basal plane* was the fastest growing seed under all conditions studied. This was fortunate as the orientation of the oscillator plates of principal interest in Western Electric production could be conveniently cut from a seed plate whose principal surface was within 5 degrees of a basal plane, and whose dimensions were about 5 in. in the *Y*-direction, and 2 in. in the *X*. The growth of such a plate was found to be mainly in the *Z*-direction. After growth the resultant quartz crystal was changed little in the *X* and *Y*, but was often 2-in. thick in the *Z* while still nearly a rectangular parallelepiped, Figure 1.

It was found that the logarithm of the rate was linearly dependent on the reciprocal of the absolute temperature, if all other parameters were held constant. Figure 2 shows this relationship for growth of the basal plane for several representative fills. It was found that if other variables were held constant, the rate was nearly linearly dependent on the temperature difference between nutrient and growth regions, Figure 3. The dependence on percent fill was slightly more complicated, Figure 4. It was found that in certain fill temperature ranges, there was a tendency for macroscopic channel-like voids, roughly parallel to the Z (crystallographic *c*) axis, to form in basal-plane growth. The fill-temperature regions where this so-called "crevice flawing" occurred were carefully mapped, and it was found that high growth rates could be achieved at fills and temperatures safely removed from the crevice flawing range. It was found that increasing the concentration of NaOH up to about 1.5*N* tended in general, to: increase rates, decrease the tendency for crevice flawing, and decrease the tendency for self- and wall-nucleation of the quartz. Further increases in NaOH usually resulted in the formation of a glassy phase in the bottom of the vessel (*11, 12*) and in excessive corrosion. Decreasing the size of the baffle opening served to decrease the rate difference between the bottom and top crystals in the growth zone, and to increase the average rate, Figure 5.

It was found that corrosion was inhibited because of the formation of sodium-iron silicate (acmite) which tended to form a protective coating on vessel walls. Preliminary laboratory data indicated that the pressures of operating vessels were 10 to 15% lower than the P-V-T data of Kennedy (*16*) would indicate for pure water.

Thus, with quantitative data on the dependence of the important variables, it was possible to make a preliminary choice of operating conditions and an estimate of the cost of plant production of synthetic quartz. It was decided that at temperatures below 400°C (752°F) and pressures below 30,000 lb./sq. in. rates of at least 40 mil/day should be possible and that these rates would make the process economically attractive. Two unanswered questions still remained:

1. Could large scale autoclaves be designed capable of operating at the desired pressures and temperatures?
2. Would there be a decrease in rate or quality due to scale-up?

Pilot plant process

The equipment used in the Western Electric pilot plant located at Merrimack Valley required a large scale-up from the laboratory facility. It was necessary to construct a temporary building for the pilot and one of the pressure vessels was lowered into place. Four pressure vessels were designed for Western Electric by commercial manufacturers of high pressure equipment (*14*). Most of the laboratory experiments had been run in vessels closed by a supported welded closure (*8, 9*), too cumbersome for commercial production. All of the pilot plant vessels used some modification of a self-energized seal (*15*). After a number of runs with water, to test the vessel seals, it was found that the only successful repetitive seal was the modified Bridgman. Body materials were Croloy or SAE 4140, both of which proved corrosion-resistant under operating conditions. The dimensions of the pilot plant vessels were 6 in. ID by 9 ft. long, with 3⅜ in. wall thickness, and their weight 4000 lb. Figure 6 is a schematic of the vessel.

The nutrient was supported in mesh baskets for ease in handling (In the laboratory, nutrient was placed directly in the vessel). The seed holder

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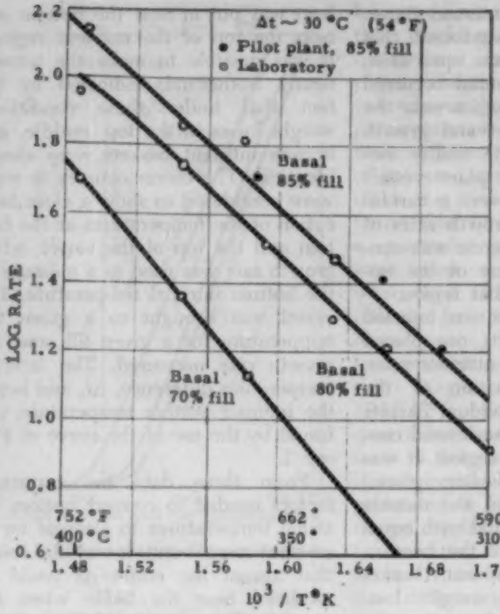

Figure 2. Log rate vs. reciprocal absolute temperature in NaOH.

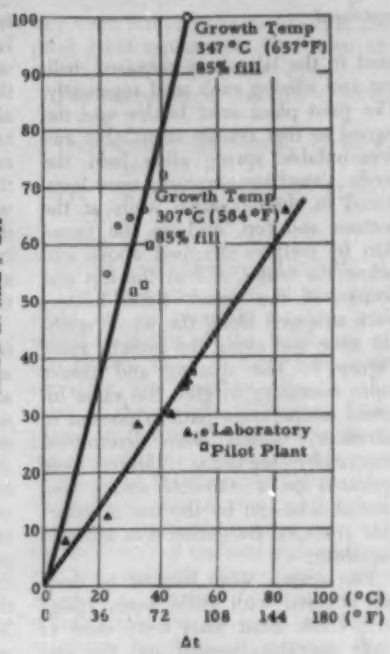

Figure 3. Rate vs. Δt for growth rate on basal plane in NaOH.

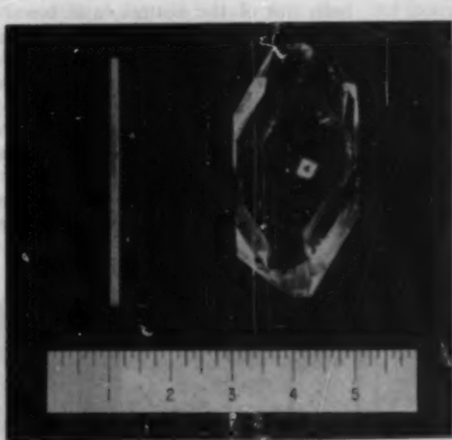

Figure 1. Seed (left) and the final grown crystal.

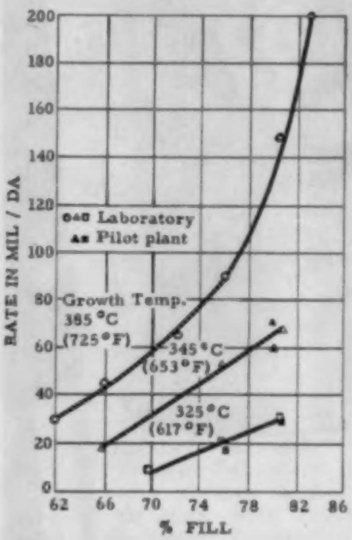

Figure 4. Rate on basal plane vs. percent fill in NaOH with Δt~30°C. (52°F.)

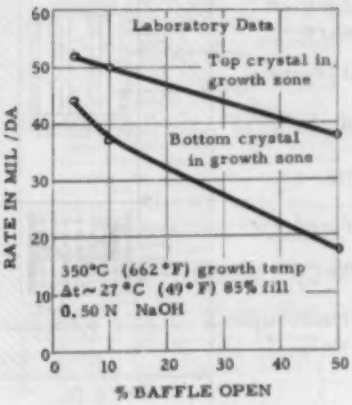

Figure 5. Rate on basal plane vs. percent baffle open.

continued

used in the laboratory required drilling and affixing each seed separately. The pilot plant seed holder was designed so that readily mountable and demountable spring clips held the seeds. Vessel temperatures were monitored in thermocouple wells at the bottom and top, and on the vessel skin by couples strapped above and below the baffle, and at the top and bottom of the vessel. Band heaters were strapped along the whole nutrient zone and along the growth zone, Figure 7. The spacing and power input necessary to give the same internal temperature pattern present in laboratory vessels were determined empirically (see below). Heaters were operated on a 440-volt source and control achieved by the use of saturable reactors. Insulation was asbestos sheathing.

The vessels were located in deep pits covered with grille work, (page 53). Cable blast mats were used to cover operating vessels and the vessels were provided with rupture discs. The control system was designed to allow maximum flexibility. Circuits for recording and controlling temperature in nutrient and growth zones separately and for recording pressure were included. Fail-safe and over-shoot controllers were provided.

It was necessary to establish that the internal conditions in the pilot plant vessels were the same as those in the laboratory, as mentioned above. In laboratory vessels it was found, that with baffles of 10%-or-less open area, the temperature differential occurred almost entirely in the region near the baffle, and the nutrient and growth zones were individually nearly isothermal. Probing pilot plant vessels was impractical; however, a careful determination of the growth rates of crystals in the growth zone was considered to be a measure of the isothermal conditions in that region.

In some runs nutrient was inserted in three separate baskets, one placed above the other in the nutrient zone, so that the determination of the weight loss of the individual baskets was a measure of the isothermal conditions in the nutrient region. It was found with identical heaters placed at equal intervals along the outside of the nutrient region, and with equal power dissipation in all the heaters, that the middle nutrient basket showed the greatest weight loss. This indicated that the hottest region was in the middle of the nutrient zone; that is, that heat was flowing both out of the bottom, and toward the top of the vessel. In some cases the top and bottom baskets were so much cooler that the nutrient in them actually began to grow; indicated by the fact that planar, regular faces were observed on the nutrient at the completion of the runs.

By spacing the heaters and regulating the power input (so that more heat was put in near the bottom and near the top of the nutrient region) it was possible to make the interior nearly isothermal; indicated by the fact that under these conditions, weight losses in the top, middle, and bottom nutrient baskets were almost identical. The thermocouples in wells were considered to show a close indication of the temperatures at the bottom and the top of the vessel; while growth rate was used as a measure of the bottom internal temperature. The vessel was brought to a given top temperature for a given fill, and the growth rate measured. The internal temperature difference, Δt, and hence the internal bottom temperature was found by the use of the curve of Figure 3.

From these data the correction factors needed to convert bottom external temperatures to internal temperatures were found; it was also found that almost the entire Δt could be localized near the baffle when the open baffle area was 2.2% and the heaters were spaced and controlled in a particular manner. Thus, within experimental error it was possible in the pilot plant equipment to reproduce laboratory data for the dependence of rate on Δt, Figure 3. Similarly, the dependence of rate on temperature, fill, and NaOH-concentration were found to approximate the laboratory relationships, Figures 2 & 4. Certain fill-temperature regions studied in the laboratory were inaccess-

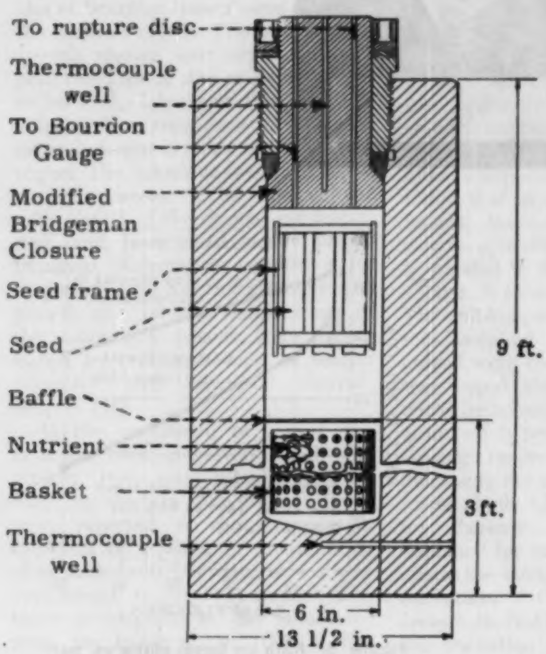

Figure 6. Pilot plant autoclave schematic.

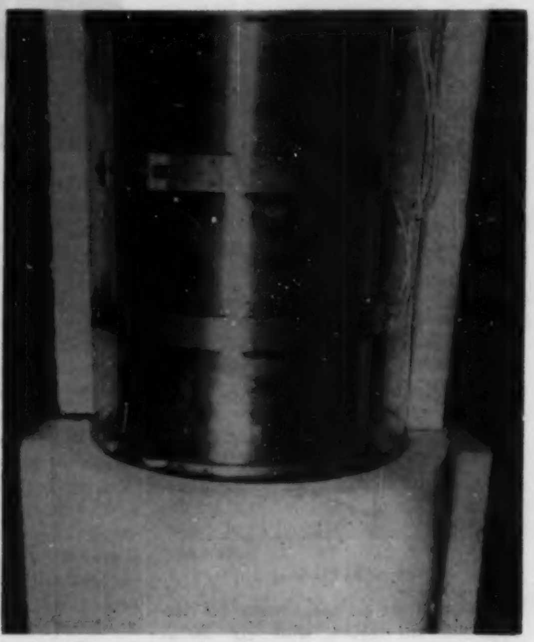

Figure 7. The heater arrangement.

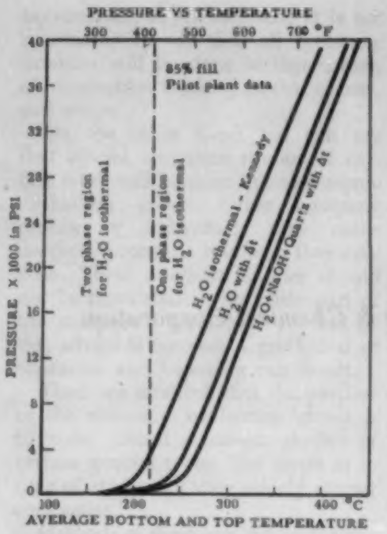

Figure 8. Pressure vs. temperature.

ible in the pilot plant equipment or impractical because of flawing, and consequently were not investigated in the pilot plant. Studies were also made in the pilot plant to find ways of increasing the initial heat input, thereby minimizing unproductive warm-up time.

The pressure in a vessel under a temperature gradient is dependent on the top temperature and the local density near the top. However, the value of the local density is difficult to calculate since it is dependent on the amount of super-heating of the solution. Progress toward the determination of the equation of state of the hydrothermal solution in the laboratory autoclaves has been made, but it was decided that direct measurement on pilot plant equipment was necessary. Figure 8 shows a typical P-T curve for a laboratory vessel. From a series of such curves, it was possible to predict pressure as a function of initial fill, temperature, and Δt. It might be noted that the pressure of quartz-saturated solutions is considerably lower than the pressure of water (*16*) or of NaOH solutions under similar conditions and that if the density used is determined by the initial fill, then some average temperature between bottom and top determines pressure.

In some of the early runs, especially those made at high temperatures and low fills, it was found that the quartz seed plate had a tendency to crack. In general, the cracks were always parallel to the longest dimension of the plate (the *Y* axis) and resembled stress cracking. This phenomenon had been previously observed in the laboratory and it had been shown that cracking occurred only when quartz was deposited on the seed plates. The tentative explanation advanced was that whenever the lattice parameters of the deposited quartz were sufficiently different from those of the seed, stresses large enough to crack the seed were set up. It was found that synthetic seeds grown at a particular temperature and fill, were most susceptible to cracking when used at a temperature and fill different from that at which they had been grown. Natural quartz seeds were satisfactory in higher temperature ranges above about 340°C (644°F) perhaps because natural quartz has been formed at temperatures in this range. In the pilot plant it was found that cracking could be prevented in the higher temperature ranges, by bringing the vessel almost to operating conditions nearly isothermally, and then slowly increasing the differential until the desired differential was obtained. In this case the lattice parameters were evidently dependent on Δt, the temperature differential. A "graded seal" was obtained by the slow increase in Δt; this means that the quartz deposited near the seed had lattice parameters like the seed, and the lattice parameters gradually changed as Δt was increased, and as material was added, until the lattice parameters were like those of the bulk of the added material; when the final Δt was reached. Since the most attractive growth rates were obtained at higher temperature ranges, the above procedure was adopted, and cracking as a problem in the pilot plant was obviated. However, although all experiments to date indicate that cracking depends on the lack of a match in lattice parameters between seed and grown material, and that the lattice parameters are dependent on temperature, fill, and temperature difference, further investigations are required before the phenomenon is adquately understood. X-ray determinations of the lattice parameters of selected samples are under way, and a careful measure of impurity content, together with a further study of the growth parameters important in cracking, is contemplated. Meanwhile an empirical method of preventing cracking in the pilot plant permits efficient operation in the fill-temperature region of economic interest.

It was found during the course of pilot plant operation, that in NaOH solutions, the system can tolerate high Δt's with little wall- or self-nucleation. As a result, rates in excess of 60 mil/day were found to be practical in the pilot plant equipment. The most attractive conditions found were:

Top temperature: 345-360°C (653-680°F)

Temperature difference: 40-60°C (72-108°F)

Fill: 80-85% (pressure 22,000-27,000 lb./sq. in.)

Baffle: 2-3%

NaOH concentration: 1.0-1.2*N*

The stones produced in the pilot plant are of excellent quality, and initial estimates of the feasibility of the process seem to have been conservative. The usability ratio, i.e., the ratio of the weight of finished filter plates to the weight of quartz starting material, for synthetic quartz, was found to be substantially higher than for natural quartz, due to the fact that the synthetic quartz was untwinned, and of uniform high quality, and the synthetic stones were nearly identical, regular parallelepipeds which could be cut with minimum wastage. In short, it appears that large-scale hydrothermal production of quartz can become an economical manufacturing process.

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LITERATURE CITED

1. Walker, A. C., J. *Franklin Inst.* *250*, No. 6, 481 (1950).
2. de Senarmont, H., *Ann. Chim. & Phys.* *32*, 129 (1851).
3. Spezia, G., *Accad. Sci.* Torino Atti, *40*, 254 (1905).
4. Nacken, R., Captured German Reports, eg. RDRC/13/18, Feb. 28, 1946.
5. Walker, A. C., *J. Am. Ceramic Soc.*, *36*, 250 (1953).
6. Hale, D. R., *Sci. 107*, 398 (1948). Also reports on Signal Corps. Contr. DA 36-039-sc-64589 and on Proj. 142-B.
7. Brown, C. S., R. C. Kell, L. A Thomas, N. Wooster, and W. A. Wooster, *Nature 167*, 940 (1951). Also Mineralogy Mag. (London) *29*, 858 (1952).
8. Walker, A. C. and E. Buehler, *Ind. Eng. Chem.* *42*, 1369 (1950). (Buehler, U S Patent 2785058)
9. Kohman, G. T., Synthesis of Quartz Crystal Final Report, Report No. 24274-D, Signal Corps Project No. 142-B, Aug. 1955. Contr. No. DA 36-039-sc-64493.
10. Laudise, R. A., *J. Am. Chem. Soc.* *81*, 562 (1959).
11. Morey, G. W., and J. M. Hesselgesser, *Am. J. Sci.*, Bowen Volume, B61 (1952).
12. Kennedy, G. C., *Econ. Geology.* *45*, (7), 629 (1950).
13. American Instrument Co., Silver Spring, Md. Thermocouple assemblies Cat. No. 45-7825 etc.
14. American Instrument Co., Silver Spring, Md.; Autoclave Engineers, Erie, Pa.; Pressure Products Co., Hatboro, Pa.
15. Bridgman, P. W., The Physics of High Pressure, Bell, London, p. 32 (1949).
16. Kennedy, G. C., *Am. J. Sci.*, *248*, 540 (1950).

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Economic evaluation *organization and coordination*

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Economic evaluation compares, for various alternative project expenditures, the expected relative profitability and, by analysis, attempts to determine how to optimize the profit from any given project or operation in relation to expenditure. The economic evaluation function is an important tool to guide top management in making decisions involving expenditures, whether for capital projects or for day-to-day operations. Because of the size and complexity of modern corporate operation, effective use of the economic evaluation tool calls for careful organization of ideas and men and continuing close coordination of the effort. In achieving a workable organization and a useful degree of coordination it is important not to lose the creative power of the economic evaluation group. If such a group lapses into a purely analytical effort, thinking may become, on the balance, negative.

Organization for economic analysis must consider:

1. organization of ideas
2. organization of people
3. coordination procedures

The first type of organization includes a consideration of such factors as establishment of the purpose and scope of the economic evaluation group; selecting the kinds of basic economic data that will be needed, and agreeing upon the sources of such data; programming economic evaluation work to cover existing operations and to cover new projects; and the determination of the qualifications and number of people required in the economic evaluation group.

The organization of people includes decisions on how the group will report in the organization to serve in a line capacity as well as a determination of how the group will assist other functional groups in the company on advisory or staff basis; selection of personnel; and establishing organizational procedures through which the economic evaluation group can get from other functional groups in the company the data needed for economic evaluations without relieving such other functional groups of essential line responsibility for the completeness and accuracy of such data.

Coordination is difficult unless top management is willing to designate the studies of the economic evaluation group as the official studies on which decision is to based. If there are to be competing or parallel economic evaluations throughout the organization, confusion in decision-making is inevitable, unless these parallel evaluations are recognized as having no official status. The data used by the economic evaluation group comes from the other functional groups in the company. The final proof of the wisdom of decisions based on economic evaluation eventually shows up in the company's financial statements. It is imperative that the economic studies tie in with the basic data sources on which all such studies must ultimately be based. These basic data sources are: research and development reports, production records, sales records, market forecasts, raw material price forecasts, engineering department cost records and project cost estimates, accounting records and financial statements. Above all, the terminology and form of economic studies should tie into the company's financial statement procedures and cost accounting terminology, methods, and reports.

Organization of ideas

Before an effective economic evaluation group can be put together and trained for its job, some advance thought and planning must be done either by top management as a whole or by the executive in charge of the function. If an economic evaluation function already has been started, then the group itself can usually be effective in advising management on the planning for further use and development of the function.

Purpose and scope. First, the purpose and scope of the economic evaluation function should be carefully thought out and defined. Is the group to make all economic studies needed by the corporation, or just studies relating to major new capital expenditures? Will the scope of the studies be limited to projects growing out of research and development, or will studies be made on optimization of manufacturing operations in existing plants as well? In other words, will the group serve only one department or all departments of the company? Will it serve on both short- and long-range economic studies?

At this stage of planning it is perhaps well to recognize that an economic evaluation group can have a strangling effect on new projects and new ideas if such a group becomes obsessed with its importance and

bureaucratic in its methods. It is not reasonable to say that all economic thinking will be done in this corner, all production thinking in that corner, and so on.

On the other hand, we can say that *official* economic studies of certain types will be done in an economic evaluation group. Other company groups or individuals may make *unofficial* economic studies as they may wish. These *unofficial* studies should not be circulated or be made part of the company's permanent records. If this advice is ignored, a great deal of confusion and bickering can result.

Thus, we establish that the purpose of the economic evaluation group is to make official economic studies of certain general types. The scope as to type of study will vary widely among companies.

Methods of approach. Second, some consideration must be given to the general methods of approach. This amounts to laying down some basic ground rules to get started. These same ground rules may themselves be a subject of study by the economic evaluation group at a later date. However, to get started, some consistent method of viewing return on investment must be defined and adopted. Terminology must be agreed upon for economic reports and this must tie into the company's accounting and financial reporting practices as closely as possible. Here the Treasurer or Comptroller and the Chief Accountant should be consulted. Some ground may have to be given at this point by the economic evaluation group for the sake of consistency and to keep peace in the family.

Agreement must be reached on the handling of depreciation—a subject in itself. The handling of interest expense is another tired, old problem that can be settled by a little clear thinking, or, if the clear thinking approach is not allowed, by arbitrary agreement. Either way, settle it and bury the hatchet!

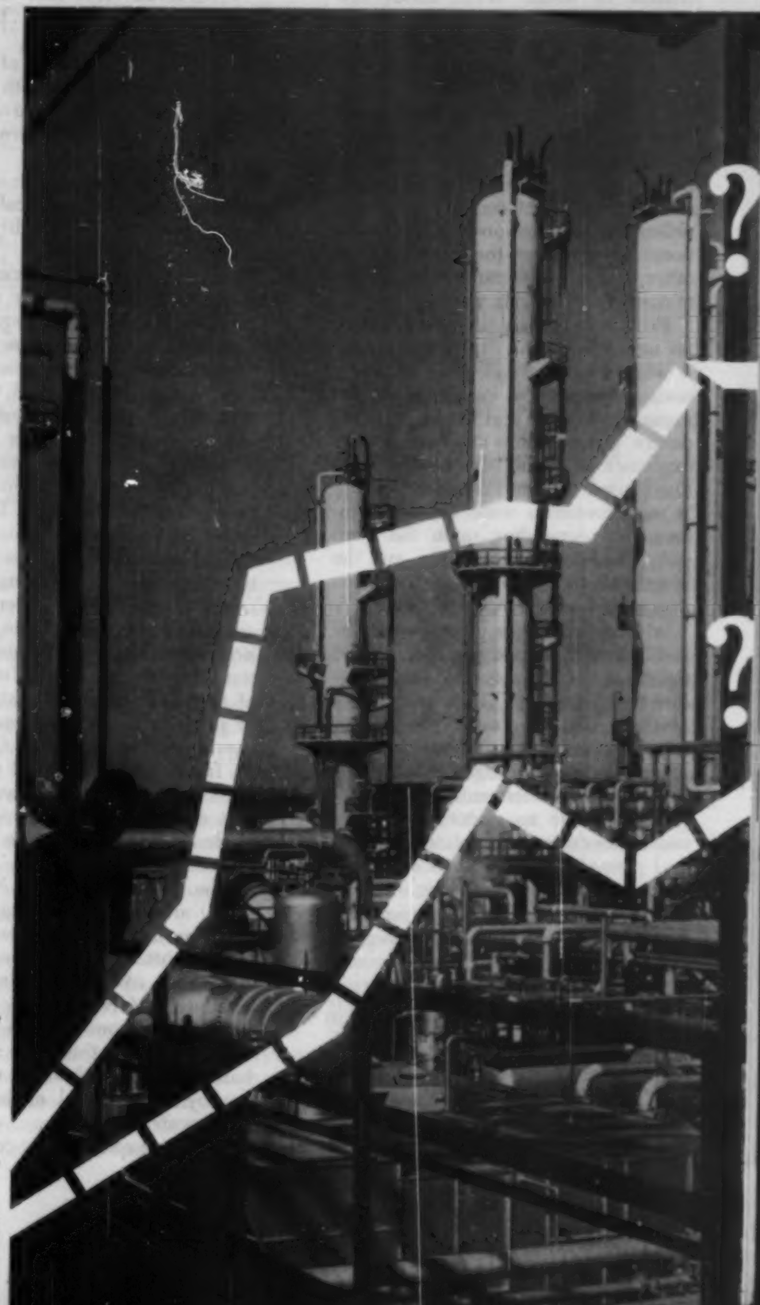
Other matters to be settled are policies that relate to the amount of working capital to be used. Here again some arbitrariness may have to be tolerated if some executive insists that the current ratio must always be at least 2.0. However, even after adopting such rigid ground rules to some extent (which is certainly not advocated here), the amount of working capital is usually determined, in the last analysis, by the character of the project.

We have to give some thought to precision limits and confidence levels. No prediction is ever exactly correct except by mere chance. How many projects have turned sour because of this sad fact of life! At least we can recognize that we are dealing with a greater or lesser degree of uncertainty and agree on ways to state this in numbers and in terminology. Even if our estimate of the uncertainty is grossly inaccurate, recognition of the lack of absolute certainty regardless of the number of decimals written down is an extremely valuable step in economic thinking.

Many other ground rules will be necessary as the economic evaluation function evolves. Old rules will be dropped and more useful ones will be adopted, for example, a switch from a "return on original total assets" method of viewing relative profitability to the "discounted cash flow" method.

Sources of data. A third important question is: what methods will be used to get the basic economic data?

continued



PROFITABILITY
how much?
how soon?

A

alternatives

B

. . . economic calculation methods, as well as cost data, do not stay current very long.

continued

Who will make capital cost estimates of varying precision levels? Will all of these, even screening estimates, be made by the Engineering Department? Who will supply estimates of conversion costs. The Research and Development Department which developed the process, or the Manufacturing Department which operates similar processes now? Will the Sales Department set selling prices or will these be set by return on investment criteria or what? What about raw material prices—whose word is to be taken, that of the Purchasing Department or that of the economic evaluation group?

Clearly, the answers to these questions will have an important bearing on the qualifications and number of people required in the economic evaluation group. Good judgment will ordinarily lean toward a small economic group using the knowledge of other company departments to the maximum reasonable degree.

Economic manual. A valuable tool for use by economic evaluation groups is what might be called an economic manual, similar in principle to the manuals prepared and used by process design groups. This manual contains explanations of all the basic procedures used by the economics group. It may contain a wide variety of information depending upon the company, the needs of the group, and the length of time the group has been organized and working together.

A new economics group would be well advised to put together a bare minimum of information on procedures and standards. Then as the work of the group progresses, the manual can be revised and extended. There is no use putting together a hodgepodge of miscellaneous information that will have no direct or frequent use. Economic calculation methods and procedures, as well as cost data, do not stay current very long.

A listing of the sort of information that will be useful in the economic manual follows:

1. Standardized terminology and abbreviations for terms used in financial statements and in economic evaluation, such as manufacturing cost of sales (MCS), profit before taxes (PBT), interest (IN), etc.
2. Standardized estimating and tabulating forms for:
   a. manufacturing cost of sales
   b. fixed capital investment
   c. working capital
   d. operating statement
   e. statement of profitability
3. Standard methods of presenting economic results graphically:
   a. Elements of yearly total cost of sales plus profit at various production rates and product price levels. This chart is usefull for determining break-even points.
   b. Elements of unit cost of sales vs. production rate with lines at various levels of return. This chart is useful in determining product selling price.
   c. Cash flow versus time chart. This chart is useful in calculating relative profitability by various methods.
4. Classification of capital cost estimates and other cost or profitability estimates as to degree of completeness and precision.

   For example, capital cost estimates might be types A, B, C and D, where A is a definite estimate with a precision of plus or minus 5 to 10%, made by a contractor bidding on a job or by the engineering department, and D is a screening-type estimate made by certain defined procedures. A D-type capital estimate might be within 20 to 30%. The other types are of graded intermediate precision. The cost of estimates and time required will be a function of degree of precision. Estimates of profitability can be graded in parallel fashion as A, B, C, and D. In general, equivalent grades of capital and manufacturing cost of sales estimates would be made at a given stage of a project.

   The papers of W. T. Nichols *(1, 2)* are the outstanding references on the subject of classification of cost estimates as to precision and cost of making the estimate. More recently Marlowe *(3)* has published a highly useful paper on this same subject based on the methods in regular use by a successful engineering and construction firm.
5. Notes or explanations covering the basic concepts used in economic evaluation and analysis, such as: the handling of depreciation and interest; the handling and estimation of selling, technical and administrative expense (STA); estimating methods for manufacturing cost of sales (MCS), fixed capital investment (FI), and working capital (WI); the concept of incremental cost and incremental profit; the definitions and use of the various kinds of break-even points; profitability estimation; estimation of selling and purchase prices according to the various different economic situations that can control these values; the propagation of error in calculations; statistical concepts applicable to economic evaluation and economic analysis.

   In recent years a number of texts have appeared that provide valuable background on the basic concepts and methods of economic evaluation. The most recent of these are the texts of Osburn and Kammermeyer *(4)*, Peters (5), Schweyer (6), and Happel (7). Happel's book is particularly outstanding. An older but still useful text is that of Rautenstrauch and Villers (8). Perry's "Chemical Business Handbook" (9) should be consulted for background as well as for specific cost estimating information.
6. Notes on the preparation of economic reports (and reports in general if no other company report writing manual is in use).
7. Basic cost data applicable to company situations such as the cost of utilities, manufacturing cost standards, labor rates, cost of local taxes, and insurance.
8. Correlated general cost estimating data and cost estimating methods used for screening-type economic evaluations. This would include a comprehensive bibliography and a copy of the more valuable papers that are most likely to apply to the work of a particular economic evaluation group or company.

   A monumental service has been rendered by J. B. Weaver *(10, 11, 12, 13, 14, 15,)* in his excellent bibliographies on cost estimation and evaluation of profitability. These bibliographies cover the literature exhaustively from 1947 to date and the more important references prior to 1947 are included. Weaver's bibliographies are a must item in an economic manual for process

industry use. Weaver has also prepared a subject index to cost data in the 3d edition of Perry's *Chemical Engineers' Handbook* (*16*).

Programming. The program of work in a given period is yet another factor to think about in advance. If deadlines for decisions are to be met with reliable studies, then there is a limit to the number and scope of the studies that a given number of men can make. Some studies may be continuing studies of no critical importance at any given time, such as establishing utilities cost. These can be routinized and can perhaps be transferred to the Accounting Department. Special studies must be done within certain time limits whether related to decision making in existing operations, that is, when to change catalyst and turn around a large unit, or whether related to new projects for capital investment.

Staffing. Having covered the five elements of idea organization and planning discussed above, we can consider the last stage, namely the number of people required and their qualifications. We must consider with this last item the degree of mechanization that will be employed, which means renting or buying computing machines to save manpower and/or time.

Neither engineers nor business school graduates emerge on graduation with mature business judgment or experience in a given company's operations. The engineer does not know business terminology; the business school graduate does not know mathematics or technology. Is it easier to teach the business school graduate mathematics and technology, or is it easier to teach the engineer business terminology? The answer is rather obvious and is substantiated by the strong preponderance of engineers in economic evaluation groups. The mathematics of business is largely arithmetic but modern economic evaluation methods involve a great deal of calculus and, as the methods of operations research are adopted, differential equations and statistics are involved to an important degree. This is not to say that the business school graduate cannot be a valuable member of the economic evaluation group, but business graduates usually should not predominate.

Does an economic evaluation man need to know accounting? Certainly not and he may be better off if he doesn't. He can master accounting terminology and basic principles very quickly on the job. He must have respect for the accountant's function and for his point of view but this is largely a personality factor—humility—which colleges unfortunately do not teach.

Texas Butadiene & Chemical Corporation

SUMMARIZED MANUFACTURING COST OF SALES ESTIMATE

(In thousands of dollars)

Project ____________

Date of this revision ________ Calculated by ______ Checked by ______

Basis: Stream days / yr ______ Stream day factor ____________ %

Annual Production ____________

____

Fixed Capital Investment basis ____________

Item	Abbrev.	Cost basis	Annual cost: Fixed	Subtotal	Total	Cost per unit of product
Raw Material Cost	RM		$	$		
1. ______						
2. ______						
3. ______						
4. ______						
5. ______						
Total RM			$	$	$	
Conversion Costs	CC					
1. Salaries & Wages (including payroll overhead)	SW		$	$	$	
2. Operating supplies & expenses	OSE		$	$	$	
3. Maintenance materials	MM					
4. Administrative & technical supplies & expenses	A-TSE					
5. Utilites	UTL					
6. Royalties	RY					
7. Local taxes	LT					
8. Insurance	INS					
9. Packaging & shipping	PSE					
10. Special supplies & expenses	SSE					
Total CC			$	$	$	
Depreciation	D					
Mfg. cost of sales	MCS		$		$	

Typical form used at Texas Butadiene in the estimation of a project. A more detailed version is used for original calculations when a project is being definitely estimated.

What about economic theory? Is this essential? Almost surely not in an economic evaluation group. In a purely business economics or economic research group, yes, but this is another function or it may be a specialized subgroup in the economic evaluation group.

To sum it up, the economic evaluation man should have:

1. a technical education or a business education with some added technical and mathematics training
2. some years of experience in research, production or engineering
3. a relatively high degree of proven judgment and proven objectivity
4. proven power of independent thinking and analysis
5. good ability in written and oral presentation
6. humility

Negative characteristics are an emotional nature and a promotional zeal. These may belong in the sales department but not in economic evaluation. Lack of the ability to write and speak clearly is an almost sure indication that a man does not belong in economic evaluation yet. Later he may overcome these deficiencies and make the grade.

There is no use to expect good economic evaluation work without competent personnel. There are enough uncertainties to be risked in business without adding hazards in the critical matter of making an objective and useful evaluation of such factors as are available for use in making our expenditure decisions. More bluntly, when you gamble you will do better when you know as much as

continued

. . .As with other functions, corporate size is what introduces complexity.

continued

possible about the odds. In the last analysis, economic evaluation tries to determine:

estimated relative expectation =
(estimated probability of success)
× (estimated relative value of success)

The estimates will be no better than the abilities of people making them.

Organization of people

Organization within the economic evaluation group. Within an economic evaluation group, organization is seldom more complex than corresponds to a group leader or supervisor or manager with several qualified men reporting directly to him. Such groups are usually not large—perhaps eight or ten men at the extreme, and more frequently three to five men. It is advisable to have at least two men working together on economic evaluation so that there is some cross-stimulation of ideas, discussion of methods, and checking of calculations. Alternately, a single-man economic evaluation group can at least work closely with a designated supervisor so that the check and balance principle will be applied.

A group of three to five well-qualified men equipped with calculating machines, and possibly with computer time available as well, can, if assisted by a reasonable amount of clerical help, make economic evaluations for a large number of projects growing out of the effort of a hundred or more technical men directly engaged in research and developmental effort. Including supporting non-technical staff and service laboratories, the total number of employees feeding projects to the three-to-five man economic evaluation group could run as high as 200 to 300.

Organization within the company. There is no special pattern for the organization of an economic evaluation group, or groups, within the company. The economic evaluation function is more often staff than line. However, within a department the economic evaluation function might well be a line function, as, for example, in a research and development department. As with other functions, corporate size is what introduces complexity.

In a smaller company that is not split up into more-or-less autonomous divisions, there will usually be a single economic evaluation group in the company. This group will most frequently be found reporting to the head of the research and development function. It may report directly to the head of manufacturing. This is probably more likely when the research and development function reports this way also. Occasionally the economic evaluation group will report to the executive vice-president or to the president.

The smaller company may gradually add more plants at different locations some of which may be to make new (to the company) product lines. If this geographical and product diversification leads to separate research and development divisions at each plant or for each of several product lines, then the economic evaluation function is apt to be split up the same way. This gives each research and development division or each company division an economic evaluation group that is familiar with the business of the particular company division.

However, complications can develop quickly as the economic evaluations made in different divisions begin to deviate in form and methods of approach. Top or central management must then revise the economic studies to conform to some more-or-less standard way of looking at such matters. Before long a new, central economics group is born, often called the coordination group or committee. Then a reverse process starts. The coordinating group begins to establish policies, investigate new methods of investment evaluation, establish uniform cost accounting practices.

Results of this effort are passed downward to the divisional economic evaluation groups. Along with the new functions just mentioned, the coordination group has often a review function. Usually all economic evaluations from the divisions pass through the central group on the way to top management. In some companies the coordinating group assumes a strong, long-range planning function which dominates its activities.

A word of caution should be injected with regard to the long-range planning function being combined with the economic evaluation function. While it is perhaps true that a central economic evaluation and coordination group can be a valuable aid in long-range planning, it is not entirely reasonable to expect such a group to take on the major planning function unless the group is composed of the top management officials of the company. It may be fashionable these days to delegate long-range planning to a staff group, but the old-fashioned expectation that the top manager is also the top planner should not be entirely forgotten. In the last analysis planning is more likely to involve the vision of an individual than the vision of a group. On the other hand, the top manager would be less than wise if he did not ask for, and get, such assistance as he needed in planning. The point is he cannot assume that planning is done when it has been handed to a group labeled "planning group."

Back in the divisions, meanwhile, the division managers begin to complain that their economic evaluators are so busy working with headquarters

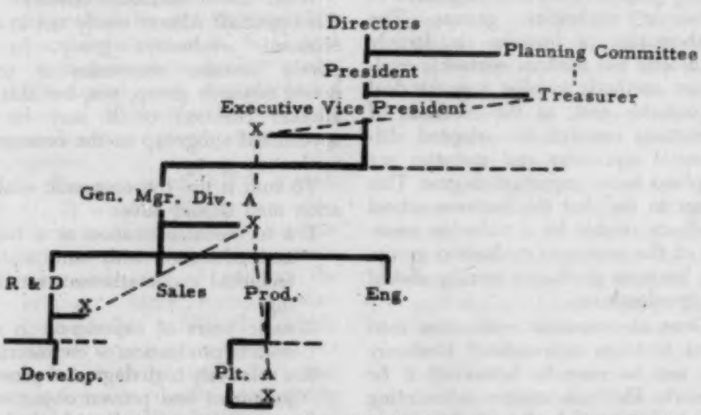
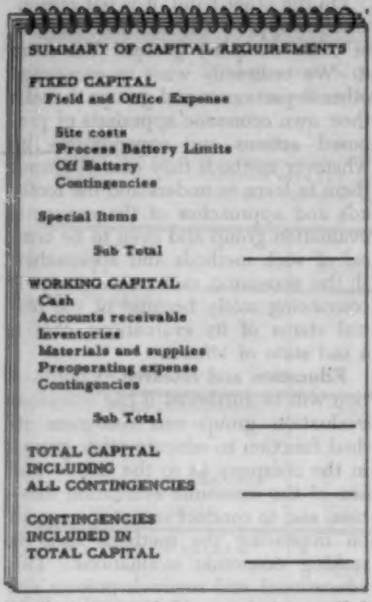


Figure 1. Typical organization for a fairly large company. Coordination paths are dotted lines.



Work sheet used to summarize capital requirements.

on dream stuff, that nobody is helping the poor refinery or plant manager with his day-to-day economic problems. The plant is now so complicated and the products so many that no quick agreement can be reached as in the old days on the optimum raw material, optimum production schedule, product-pricing matters, and many other problems.

The manager of the divisional economic evaluation group decides to split his men up into subgroups, devoting one to short-range and one to long-range problems. In general, the short-range men work on economic analyses involving the optimization of existing operations while the long-range boys work on capital investment projects of a major nature. More often than not the capital investment projects grow out of research and developmental effort. Since there is no sharp dividing line, and since each subgroup still needs the help of the other, the two subgroups are frequently left under the same manager and in the research and development department.

On the other hand, the short-range group may be placed under the manager of manufacturing. If this split leads to coordination difficulties, the division manager may haul both economics subgroups out of their respective departments and realign them together in staff position reporting directly to him.

While the tendency to place economic evaluation function within the technical and/or production groups is very strong in the process industries, it is by no means the only method of organization. The economic function may be under the divisional comptrollers and the company's treasurer or chief financial officer. In such cases, the comptrollers and the chief financial officer will be men with a broad knowledge of the business of the corporation. Technical men will be needed in the economics groups but there will be a tendency to bring in more men trained in graduate schools of business rather than in engineering. If such business school training gets too much emphasis in the economic evaluation groups serving a highly technical operation such as petroleum refining or synthetic organic chemicals, the manufacturing and research departments may not be served effectively. This can lead to "private" economics groups springing up here and there to do work vaguely described as "screening effort only." Before long, a bad situation can develop in which the more technically oriented people try to "sell" their economics to the business people who are apt to be characterized as simply negative analyzers who can prove in advance that any project will be a bust. It is not necessary to go further with the picture of confusion that can result.

A typical organization for a fairly large company is shown in Figure 1. The dotted lines indicate the coordination paths that are most likely to be followed.

Coordination procedures

Top management recognition of need. Perhaps the most important over-all coordination procedure in the economic evaluation function, as in any other corporate function, is a firm statement by the chief executive officer of the corporation, or of a corporate division, of *what* is needed, and a correspondingly firm designation or recognition of which group is expected to fulfill the need. This sort of firm executive direction is especially needed in the case of the economic function. Merely to say "make a study of the economics of a situation" is almost always not specific enough to be useful unless the organization and the economic evaluation group have had long experience in guessing what the big boss wants.

Further, the economic evaluation group likes to know whether a definitive or a screening study is wanted. Is the emphasis on speed, or is there a reasonable and specified period for completion so that other work can also be scheduled? Is there any particular point of emphasis, such as a study of the selling price prospects and patterns when the project is considered sensitive to selling price? Is the rest of the organization aware of the request for, and purposes of, the study to a reasonable extent? Are any particular departments or staff groups to be drawn in on the study more heavily than usual for some particular reason? These kinds of questions can often be anticipated and answered in advance — a practice that will greatly assist coordination.

Coordination with accounting and financial procedures and reports. Second in importance after recognition by the chief executive of either a specific need or general needs, is the matter of coordination of terminology and form of economic evaluation reports with company cost accounting and financial reporting procedures. If the economic evaluation function comes long after the accounting and financial report precedents are set, the economic evaluation group may have to give a great deal, hoping gradually to induce changes in outmoded or misleading accounting practices. Changing the form of financial statements is even harder but not impossible.

Ideally, the comptroller's people should sit down with the economic evaluation people and work out together the most useful, convenient and appropriate-to-the-company terminology and form. Such agreements should then be checked with any department head who will listen and give advice or make constructive requests for additions or changes to help him in some particular way.

Internal procedures and practices. Focusing now on the economic evaluation group rather than on the instructions to this group, there are a number of coordination principles that can be useful, some of which are so obvious as to be almost always overlooked.

Studies should be internally consistent, arithmetically and mathematically accurate (even though the basic data may be uncertain) and figures should be rounded off consistent with the estimated precision of the basic data. Nothing starts confusion like haggling over differences in figures which either are just inconsistent rounding-off practices, or are arithmetical errors not picked up in checking the study before it is submitted. Such time-wasting practices are inexcusable.

Next comes the question of nomenclature, symbols, and just plain English. Standard nomenclature and sym-

continued

bols should be adhered to and frequent definition lists and legends should be included. Executive memories are short for such details, and they should be. The use of plain English instead of the usual economics jargon and gobbledygook is even more important than in a technical report. Not much text is needed if the study is any good. Long-winded "discussions" are completely unnecessary. One chart is *not* necessarily worth a thousand words but one chart *and* a supporting table can be. Many executives are not "graph-oriented"—they are "table-oriented." Use both and be safe, but explain the graph with adequate coordinate labeling, main titles, and legends, and clarify the table with adequate headings and footnotes that are consistent with the parallel graph.

As the study is being made, it is wise to check the various parts with the interested and affected departments or staff groups. The engineering department wants to be sure its estimates are adhered to and presented properly with any qualifications originally given. The manufacturing people will be asked about the manufacturing cost of sales estimate. Why not check it with them in advance and save all the wrangling that can occur later? If a deliberate "judgment" departure is made from one of the estimates from a supporting department, this should be clearly stated with the reasons for it.

Reconciliation and review. Economic evaluators cannot always be right. It is sufficient if their errors are customarily within the realm of good, experienced judgment. A rare combination of foresight, tact, and humility is needed in arriving at this judgment and in accepting the inevitable deviations that show up later in practice. Arguments as to whether the deviations were because "the figures were wrong in the first place", or because the performance of this or that operating group was below standard, usually produce little result except human friction.

Nevertheless, reconciliation of estimates with results, if done objectively, can be a valuable coordination tool. Where did the estimate go wrong and why? If this double-barreled question can be answered specifically and honestly, coordination will be found improved on the next study because everyone likes to progress forward and avoid making the same mistakes twice.

It is useful to review economic evaluations broadly in light of financial results. A logical place to do this is in the internal financial statements. (It is not practical to do this in the public annual or quarterly reports for obvious reasons.) Here we get a check on whether the economic evaluation can indeed be reconciled with the accounting records. If not, steps can and should be taken so predictions and actual results *can* be compared usefully.

It is not at all unreasonable to set up a review board which would act as a control on the effectiveness of the economic evaluation function and its use as an aid to making top management decision. This review board might consist of the treasurer, the president, and selected members of the board of directors. The review board might ask and obtain answers to such questions as:

1. Does the economic evaluation function give the kind of answers wanted in time to be used effectively?
2. Are the evaluations borne out by actual financial results most of the time?
3. Does the rest of the organization make sufficient use of the economic evaluation group or groups?
4. Is the cost of the economic evaluation effort in reasonable relationship to desired results or should more or less money be spent to get more or the same results?
5. Are the methods of the economic evaluation group or groups up to date and do the methods place company projects in perspective with what competing companies are doing?

Official vs. unofficial economic evaluations. As suggested previously, recognition of the official status of the evaluations of the economic evaluation group or groups is an important coordinating procedure. As soon as the company organization as a whole appreciates that top management recognizes only the official economic evaluations for decision making, it is natural for the various departments to cooperate. For example, if the production people realize that a new tank farm section will be approved only after the economic facts are evaluated officially, effort will normally be made to get the necessary data to the economic evaluation group, even if this means that production pushes engineering for a capital cost estimate, etc.

On the other hand, it is not reasonable to suppress all economic thinking of other company groups. Far from it. We ordinarily want to encourage other departments and groups to make their own economic appraisals of proposed actions and expenditures by whatever methods they can. We want them to learn to understand the methods and approaches of the economic evaluation group and even to be critical of such methods and approaches. If the economic evaluation group is convincing solely because of the official status of its evaluations, this is a sad state of affairs.

Education and research. Coordination will be furthered if the economic evaluation group can recognize its dual function to educate other groups in the company as to the nature and use of the economic evaluation function, and to conduct constant research on improving the methods used in making economic evaluations. This educational and research process can take many forms: definitions and explanations of terms; development of cost correlation and control procedures for other groups; development of economic evaluation techniques to be transferred to production, purchasing, and sales groups for their own use; assistance to the cost accounting group to increase understanding of expense classification in a complex, highly technical operation; the training of staff for economic evaluation work within other company departments, e.g., for day-to-day short-range economic studies within the production department, or under the plant manager and so on. For top management, the educational function may include studies of methods of measuring relative profitability and comparisons of past project performances with predictions.

Project evaluation vs. project promotion. It is desirable for the economic evaluation group to be divorced from project promotion if possible. This is often difficult to achieve in medium- and small-sized companies where the research, engineering, or production departments may handle economic evaluations. Then, of course, it is always difficult for the most dedicated economic evaluator not to finally form an opinion and a prejudice of his own. Perhaps the thing to do is to recognize openly the human problem involved. Then the top executives can emphasize the tremendous responsibility that rests on the economic evaluation group, expecting that such a feeling of responsibility may encourage objectivity to a greater and more practical degree than attempts at "isolation" methods.

Texas Butadiene & Chemical Corporation.

ESTIMATED PROFIT AND LOSS STATEMENT

Project: ______
Date of this revision: ______ Calculated by: ______ Checked by: ______
Basis: Stream days /yr: ______ Stream day factor: ______
Annual production: ______

	Abbr.	Thousands of Dollars per year		Per unit of product
GROSS SALES 1. 2. 3. TOTAL GROSS SALES	GS	$	$	
LESS SALES DEDUCTIONS 1. Freight allowed 2. Discounts 3. Returns TOTAL SALES DEDUCTIONS	SD	$		
TOTAL NET SALES	NS		$	
MFG. COST OF SALES 1. Raw material cost 2. Conversion costs 3. Depreciation 4. By product credits a. b. etc. TOTAL MFG. COST OF SALES	 RM CC D BPC	 $ $ $ $( ) $		
SELLING, TECHNICAL & ADMINISTRATIVE	STA	$		
INTEREST	INT			
PROFIT BEFORE TAXES	PBT	$		
FEDERAL INCOME TAXES	FT			
PROFIT AFTER TAXES	PAT			
ADD: 1. Depreciation 2. Amortization CASH ACCUMULATION	 D A CA			
FIXED CAPITAL INVESTMENT BASIS			$	

Form for operating statement used to report estimated profit and loss on a project.

Creative thinking. Finally, the economic evaluation group must recognize that an approach which is merely analytical is not necessarily enough. Project synthesis need not end when the economic evaluation group goes to work. Evaluations done in such a way as to create broad economic perspective can stimulate other groups to new approaches that can turn a "not quite good enough" project into a definitely attractive one. Perhaps the research department did not ask for enough cases to bring out the attractive economics of a larger scale of operation. Perhaps the production department did not consider the merits of stepwise installation of the highest payout equipment first, the next best second, and so on. Are engineering and construction codes and standards too high and too rigid in view of the nature of the project? Management may not have realized the economies possible if sales agents are avoided and existing sales staff and facilities used for a new product line. If questions like these can be induced (without at the same time inducing antagonisms), then creative thinking by many individuals in the several departments may produce a new approach to the project that can save it or may suggest an altered and more promising project along lines similar to the old one.

Management knows that it is not easy to find and develop new projects in the first place. Evidence of continued negative thinking or economic astigmatism on the part of the economic evaluation group will often start a reaction damaging to coordination and poisonous to morale in several, if not all, departments.

There is no lasting place in an economic evaluation group for the mind that is merely analytical rather than creative *and* analytical. There is still less place for purely negative thinking. A good project turned down by an analyst lacking the imagination to see how the project could succeed, perhaps with some unobvious change in approach that would reduce or suitably stage the risk, is a real loss. Most developmental projects are too risky for investment anyway. If the analyst can't tell a good project, can he tell a poor one? If he can't discern clearly between the good risks and the poor, the law of averages says the development program will be a failure. If he turns down all projects, failure of the development program is absolutely certain. Nothing can be more frustrating to research and development people, especially the really creative ones, than economic evaluation that is only negatively analytical bringing nothing whatsoever to the project but the cranking out of numbers according to pre-set routines.

Proof of the pudding. When the services of the economic evaluation group are oversubscribed by all departments and top management alike, and when a waiting line forms for the assistance that the economic boys can give, coordination can scarcely be a problem for long, nor can there be much doubt as to the quality of the economic evaluation effort.

1. Nichols, W. T., *Chem. Eng.*, *58*, 248, 250 (June, 1951).
2. Nichols, W. T., *Ind. Eng. Chem.*, *43*, 2295-8 (October, 1951).
3. Marlowe, G. J., A.I.Ch.E., New York Sect., All-Day Symposium, (October 18, 1956).
4. Osburn, J. O. and Karl Kammermeyer, "Money and the Chemical Engineer," Prentice-Hall, Inc., Englewood Cliffs, N. J. (1958).
5. Peters, M. S., "Plant Design and Economics for Chemical Engineers," McGraw-Hill, New York (1958).
6. Schweyer, H. E., "Process Engineering Economics," McGraw-Hill, New York (1955).
7. Happel, John, "Chemical Process Economics," Wiley, New York (1958).
8. Rautenstrauch, W. and Raymond Villers, "Economics of Industrial Management," Funk (1949).
9. Perry, J. H., "Chemical Business Handbook," McGraw-Hill, New York (1954).
10. Weaver, J. B., *Chem. Eng.*, *61*, 185-98 (October, 1954).
11. Weaver, J. B., *Chem. Eng.*, *62*, 247-52 (June, 1955).
12. Weaver, J. B., *Ind. Eng. Chem.*, *48*, 934-42 (May, 1956).
13. Weaver, J. B., *Ind. Eng. Chem.*, *49*, 936-46 (June, 1957).
14. Weaver, J. B., *Ind. Eng. Chem.*, *50*, 753-62 (May, 1958).
15. Weaver, J. B., *Chem. Eng.*, *61*, 881-88 (April, 1954).
16. Perry, J. H., Chemical Engineers' Handbook, McGraw-Hill (1950).

Presented at the A.I.Ch.E. Golden Jubilee meeting in Philadelphia.

Air cooling in chemical plants

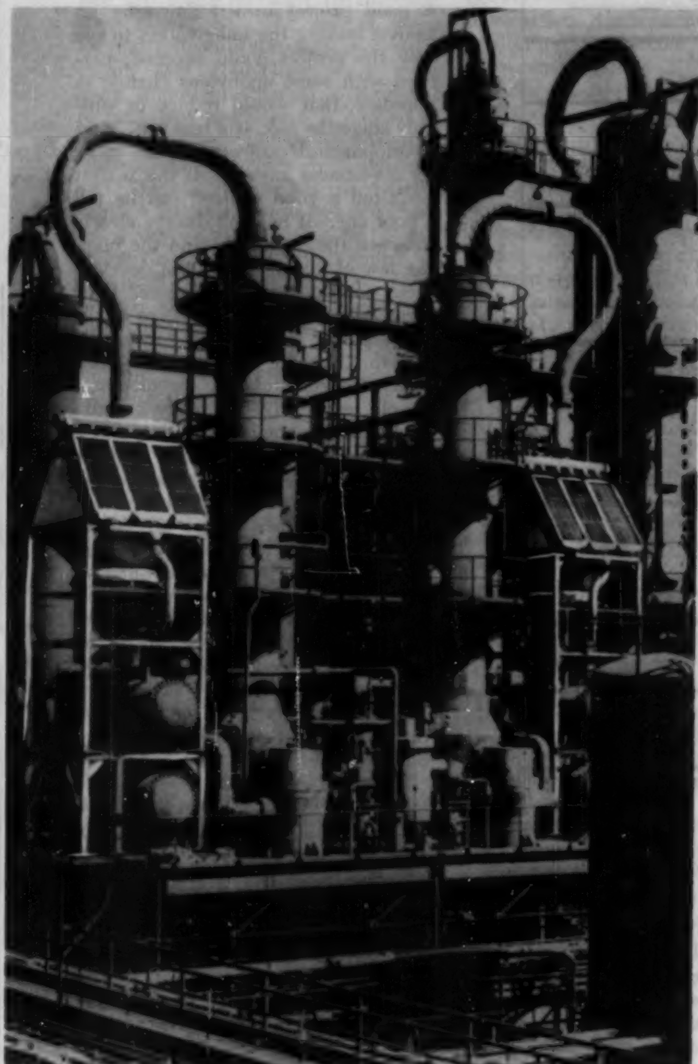


Figure 1. This German process plant has a typical installation of air cooled heat exchangers. (Left and right.)

R. T. Mathews
Engineering Department
E. I. du Pont de Nemours & Co.

In the United States, the major use of air cooling has been by the oil and pipe line industries. While applications of air cooling have been made in chemical plants, these have been largely in water scarce areas. The chemical industry should give greater consideration to the use of air cooling because this industry uses about 24 percent of the water required by all manufacturing industries.

In Germany, where the cost of water for industrial use has increased rapidly since World War II, air cooled exchangers are being used in both oil refineries and chemical plants, with supplementary evaporative cooling being used above 70°F. ambient air temperature. Compact air cooled exchangers have been installed in Germany on the roofs of buildings or on process equipment structures. These exchangers use elliptical tubes to reduce air pressure drop, deep tube bundles to conserve space, vane axial fans to provide necessary static air pressure, and venturi stacks to prevent air recirculation and conserve fan power. A typical installation of air cooled exchangers located in a German process plant is shown in Figure 1.

Four broad areas for the application of air cooling in chemical plants are:

a. Where initial investment savings and/or operating savings will justify the installation of air

cooled exchangers. This includes high maintenance and high water consumption applications.

b. Where allocated investment savings in cooling water facilities, pipe lines, and disposal facilities will justify installation of air cooled exchangers.

c. Where critical water shortage or growing water scarcity makes the use of air cooled exchangers more or less a necessity.

d. A combination of any two or more of these conditions.

Table 1 provides some practical guidance to the areas where individual air cooled exchangers should be investigated further and the design conditions under which they may prove economically attractive.

The following design conditions appear to have the major effects on the economic selection of air cooled exchangers:

1. Operating costs. The design conditions outlined in Table 1 will affect the total investment cost of air or water cooled exchangers. Operating costs should be determined separately for comparative evaluations. However, as a quick guide, the design conditions listed in Table 1 which are favorable to air cooling on an investment basis will usually indicate favorable operating costs. Conversely, unfavorable design conditions will usually indicate high operating costs.

The operating costs which will have a controlling effect on evaluations of air versus water cooled exchangers are maintenance and cleaning of exchangers, power costs for air cooler fans, and water supply, treatment and disposal costs.

Definite maintenance and cleaning costs for either air or water cooled exchangers in chemical plants are difficult to obtain on a basis which will permit the drawing of general conclusions. A large part of the water cooled exchanger maintenance and cleaning is caused on the water side, usually as a result of a combination of high process temperatures, and the quality of available cooling water. As a guide, a ratio of approximately 4 to 1 for cleaning and maintenance costs is suggested for water versus air cooled exchangers, when detailed cost records are not available. This ratio will probably increase for brackish or contaminated water and decrease for clean water.

The major "out of pocket" operating cost for air cooled exchangers is for electric energy for fan motors. Except for air cooled exchangers with one fan and a single-speed motor, the average power requirements are considerably less than the total rated motor capacity. Where the air flow can be reduced to 75 percent or less for a large percentage of the year, two-speed motors will result in substantial

power savings. Power savings can also be realized by the use of automatic, controllable - pitch propeller fans.

The largest operating-cost saving by the use of air cooled exchangers is usually the reduction in water supply, treatment, and disposal requirements. These costs must be based on local conditions and will vary widely.

2. Allocated facility costs. Allocated facilities ($/g.p.m.) is defined as the investment cost of cooling water facilities, including distribution water lines to the battery limits of a process area divided by the firm capacity of the cooling water system. These cooling water facilities are charged against each user in proportion to its water demand. Allocated costs ($/kw) for electrical facilities are determined in a similar manner.

3. Heat transfer design conditions. A small LMTD and close temperature approach can result in considerable exchanger surface, air flow, and fan horsepower per million Btu./hr. of heat removed. Analysis of process conditions may indicate that outlet fluid temperature, normally used with water cooling, cannot be economically justified. The design-dry-bulb air temperature should not be the maximum temperature of record for the area, but the temperature which can be exceeded for a reasonable number of hours per year.

The conventional horizontal air cooled exchanger is most economical when the tube length is 24 feet or longer. A process-side pressure drop of less than 1 lb./sq. in. is costly. For economical design, a pressure drop of less than 1 lb./sq. in. per pass should not be specified.

Dirt on the air side extended surface of an air cooled exchanger, unless it restricts air flow, has no appreciable effect on heat transfer. While the transfer coefficient on the water side of a water cooled exchanger is considerably greater than air, fouling

continued

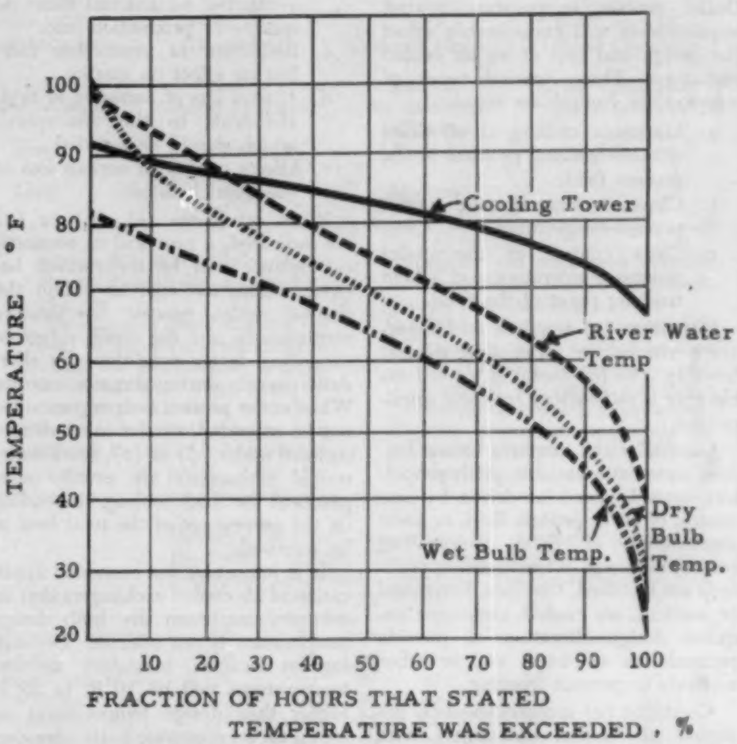


Figure 2. Annual temperature probability curves for a plant location.

Air cooling in chemical plants

continued

factor corrections for actual cooling water conditions reduce this advantage.

Process side coefficients below 200 Btu./(hr.) (sq. ft.) (°F.) referred to the outside bare tube area usually result in air cooled exchangers with total heat surface favorable with water cooled exchangers on a comparative cost basis.

4. Cooling method. Where the air cooled exchanger replaces a water cooled type and can be located close to the process equipment, it has its best economic advantage, as compared with water cooling. When the process heat is transferred in some type heat exchanger device to a secondary fluid which is then cooled by flow through the air cooled exchanger, the investment and operating savings will be less attractive.

5. Materials of construction must satisfy both the process and water side requirements of water cooled exchangers. However, for air cooled exchangers, only the process side requirements are controlling. This allows greater freedom in selecting materials of construction with considerable saving in initial investment.

6. Process temperature control. Outlet process temperature control requirements will considerably effect the design and cost of an air cooled exchanger. Three general types of temperature control are required:

a. Maximum cooling at all times with no freezing problem of the process fluid.
b. Close control of the outlet process temperature.
c. Close control of the outlet process temperature and a high freezing point of the fluid.

Condition (a) requires no temperature control or protection against freezing. The horizontal air cooled exchanger is satisfactory for these applications.

Condition (b) requires either louvers, automatic variable pitch propellers, variable speed fan drives, by-pass control of air or process fluid, or some combination of these temperature control methods. When freezing problems are involved, the open, horizontal or vertical, air cooled exchanger requires design alterations to provide recirculation of warm air, or other methods to prevent freezing.

Condition (c) requires specially designed air cooled exchangers with recirculated warm air and heating coils to maintain proper metal temperatures at all times.

7. Process equipment arrangement and piping. The arrangement of a chemical process area has an important influence on the economic application of air cooled exchangers. When units are designed into the original process arrangement, adequate space and structural supports are provided. Problems of air recirculation can be more easily overcome, process piping may be shortened, and water lines and sewers in the process area may be reduced to a minimum. The space problem of air cooled exchangers can be overcome in some cases by locating this equipment above pipe alleys or over other process equipment.

8. Design air temperature. When close process outlet temperature approach to the dry bulb temperature is required in an air cooled exchanger application, careful analysis of the effect on process conditions of exceeding design temperature is required. This analysis usually indicates one of the following process conditions exists:

a. No effect on process conditions. Specified temperature is obtainable with water cooling but not required.
b. Causes loss of chemicals through vents, but no material effect on quality or production rate.
c. Reduction in production rate, but no effect on quality.
d. Causes loss of corrosive or toxic chemicals to the atmosphere which should be avoided.
e. Affects quality or serious loss of valuable chemicals.

When conditions (a), (b), or (c) are indicated, a practical or economical balance can be determined between additional cost to obtain the desired outlet process temperature continuously, and the disadvantage of exceeding design conditions for short daily periods during summer months. When outlet process temperature must not be exceeded, similar to conditions outlined under (d) or (e), small water cooled exchangers are usually most practical for final cooling, depending on the percentage of the total heat to be removed.

It is important for economic application of air cooled exchangers that an *arbitrary* maximum dry bulb design temperature is not selected. Depending on location, maximum ambient temperatures will be 10°F. to 20°F. higher than design temperatures selected on an economic basis, considering process conditions.

Ambient air temperatures, except for short periods, will usually be lower than cooling tower and (some) river water temperatures. This is illustrated in Figure 2 which shows a plot of annual temperature probability curves for a plant location. The cooling tower curve is based on manufacturer's performance data, but does not include any allowance for higher outlet water temperature due to recirculation. The river water temperature curve was based on temperatures for the year 1956, which was an unusually dry year for this location.

Economic evaluation

The economics of air versus water cooling may be considered on both a short- and long-term basis. The short-term basis of economic evaluation reflects current project investment and potential operating cost savings. The long-term economic evaluation reflects current project investment, as well as long-range investments in water facilities, and anticipated operating costs.

Table 1, Column 1, allows selection of air cooled exchangers on a short-term basis, while Columns 2, 3 & 4 provide for evaluation on a long-term basis.

An important index in the economic comparison of air instead of water cooling on a complete project basis is the percentage of the total heat removed above a process outlet temperature, equal to the selected dry bulb design temperature plus 25°F. If this percentage is 75 percent or greater, and the allocated costs for water facilities are \$50/g.p.m. or higher, air cooled exchangers offer attractive possibilities and warrant further investigation. Although individual air cooled exchangers may appear marginal in certain cases, more-than-compensating economies may be realized by maximum reduction of investment in cooling water facilities, water piping, and sewers.

Problems of air cooling

Some problems of air cooling are:

1. Atmospheric corrosion. Care should be exercised that air coolers are not placed where corrosive vapors and fumes from vents or stacks will pass through them. Also, the exhaust steam from vent stacks should not condense on the air cooler. The nature of chemical fumes in the general area where an air cooled exchanger is to be located should be carefully considered in the selection of extended surface materials exposed to the atmosphere.

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Table 1

Application guide for air cooled heat exchangers

The values listed in this table are estimated limits for the items considered and may be used either individually or collectively. As a guide, if ten favorable items are listed in Columns 1, 2 and 3 for an air cooled heat exchanger under consideration, further investigation is advisable. At least five of the favorable items should be those shown with an asterisk.

DESIGN CONDITIONS FOR WATER OR AIR COOLED EXCHANGERS WHICH DETERMINE THE ECONOMIC SELECTION

JUSTIFICATION FOR SELECTION	Lower Project Investment and/or Lower Operating Costs	Savings in Allocated Facilities Plus Savings from Column 1		
ECONOMICS OF AIR COOLING	Column 1 Attractive	Column 2 Attractive	Column 3 Favorable	Column 4 Marginal or Unfavorable
*1 Allocated Facilities $/g.p.m.	—	100	50	25
*2 Temp. Approach °F. (a)	50	50	25	15
*3 LMTD °F.	125	100	75	30
*4 Water Side Fouling Factor	.003	.002	.001	.0005
*5 Process Side Heat Transfer Coefficient (b)	1-150	1-200	200-400	400-1000
*6 Process Side Pressure Drop, p.s.i.	10	10	1	0.1
7 Water Temp. Rise °F.	10	10	25	40
8 Design Pressure, p.s.i. abs (c)	above 1000	above 500	above 15	below 15
9 Design Temperature °F.	above 400	above 300	above 200	below 150
*10 Cooling Method	Process Cooling	Process or Intermediate Fluid Cooling (d)	Process or Intermediate Fluid Cooling	Intermediate Fluid Cooling
*11 Materials of Construction Water Cooled Exchangers	Bimetallic Tubing or Special Materials Because of Water Side			Materials the same Either Exchanger
Air Cooled Exchangers	Materials Required only for Process Side Conditions			
12 Design Air Temperature °F. (f) and (%) exceeded annually	85-(3%)	90-(2%)	95-(1%)	100-(0.1%)
13 Temperature Control	Manual	Manual	Automatic	Automatic
*14 Process Freezing Temp. °F.	below 0°F.	below 0°F.	32°F.	100°F. or higher
*15 Cleaning Process Side (e)	None Required	Clean Fluid	Chemical Cleaning	Hand Cleaning
16 Recirculation—Down Drafts from Structures	None	None	Possible	Poor Conditions
17 Structural Supports	Ground Mounted	Ground Mounted	No Structural Difficulties	Special Structures
18 Length of Process Piping	Short	Short	Medium	Long
19 Length of Water Piping and Sewers	Long	Long	Medium	Short

Footnotes

(a) The use of water cooled exchangers in series with an air cooled exchanger is often times more economical than complete air coolers. As a guide, if 75% of the process heat can be removed above 150°F., air cooling should be considered.

(b) Process side heat transfer coefficients below 200, including process side fouling factor, usually favor air cooling except clean fluids where extended surface can be used on the process side. Heat transfer coefficients are all referred to the outside surface area based on the bare tube outside diameter.

(c) Air cooled exchangers are usually more economical than drip coolers for design pressures over 1000 p.s.i.

(d) "Process Cooling" is used to define those cases in which the process fluid is actually cooled by flowing through the air cooled exchanger. "Intermediate Fluid Cooling" is used to define those situations in which the process heat is transferred in some type heat exchanger device to a secondary fluid which is then cooled by flow through the air cooled exchanger. (Cooling of jacket water for engine and compressor cylinders would be classified as "Intermediate Fluid Cooling").

(e) When frequent process side cleaning, which can not be done by chemicals, is necessary, conventional air cooled exchangers should be avoided, unless removable coverplates are used and special provision made for hand cleaning.

(f)

Plant	Maximum Dry Bulb Temperature °F	Dry Bulb Temperature °F % of Annual Hours Stated Temperature is exceeded 1%	2%	3%	Annual Average Dry Bulb Temperature °F	Suggested Design Temperature °F
Beaumont, Texas	102	93	91	90	69	91
Victoria, Texas	110	89	96	95	71	96
Parkersburg, W. Va.	106	90	87	86	55	87
New Orleans, La.	102	92	91	89	70	91
Wilmington, Del.	106	88	85	84	55	85
Grand Rapids, Mich.	99	83	80	78	47	80

1% = 88 hours 2% = 175 hours 3% = 263 hours

Air cooling in chemical plants

continued

2. Fire hazard. A fire hazard can exist from leakage of chemicals into the air stream, but numerous design precautions can be taken.

3. Toxic fumes hazard. A hazard can occur from leakage of toxic fumes. Careful attention to design, fabrication, and location of the air cooler can minimize this hazard.

4. Maintenance and cleaning. When hand cleaning is necessary on the process tube side, and the rated pressure is above about 150 lb./sq. in. special designs should be considered, or the cost of cleaning should be evaluated. When chemical cleaning can be used, conventional air cooler designs should be satisfactory. Cleaning of the air side is not a real problem.

5. Lower outlet process temperatures. When lower outlet process temperatures are required than can be obtained with air cooling, three solutions are available. These are: final cooling by water, evaporative cooling, or air cooled refrigeration, depending on the economics of the cooling water supply.

Some of the following problems may occur from attempting to use currently available air cooler equipment for chemical plant applications:

1. Space. The ground area or projected area occupied by the air cooler is usually considered one of the chief objections to using this equipment.

2. Noise. Sound level measurements conducted on a number of air coolers indicate that, if proper consideration is given to the use of two-speed motors, limitations on fan tip speed, and proper design of the fan and air cooler, noise should not be a problem.

3. Freezing of process fluids. The conventional design of horizontal air cooled exchangers offers poor protection against freezing of high melting-point process fluids, and for such applications they are not recommended.

4. Air recirculation. Warm air recirculation, especially from forced-draft air cooled exchangers, is a problem under some conditions during hot weather periods. The use of stacks or induced draft units will usually overcome this problem.

5. Process temperature control. Process temperature control to within 2°F. to 3°F. by the use of louvers, air or process by-pass controls, or automatic variable pitch propellers, is indicated by air cooler manufacturers. Adjustment for changing ambient air temperatures do not appear to be a problem in maintaining constant process temperatures. However, sufficient experience is not available to indicate how rapid a change in process fluid temperature can be corrected when compared with water cooling.

6. Fans and drives. Large fans and drives are more subject to critical speeds and vibration. To avoid critical speeds and vibrations, fans for suspended drives should be limited to 10 ft. diam. and (usually) 25 hp.

7. Vertical tube exchangers. A vertical or steep sloping air cooled exchanger is required for some process condensing applications. While vertical coil exchangers with horizontal tubes are available, vertical tube exchangers are not common in American practice.

New design requirements

While current designs available from manufacturers can be used for many process applications, the effective and full use of air cooling will not be realized until new designs are developed more suited to the needs of the chemical industry. The requirements of a new design can be grouped into five categories.

Reduced space requirements can be realized by the use of suspended fan drives, higher static pressure fans, and (in some cases) elliptical tubes to provide a more compact exchanger. Vertical tube exchangers are required for some process applications, and with vertical air discharge, should be a practical unit, occupying a minimum of space.

Temperature control. The air cooled exchanger, to be more practical for many chemical plant applications, will require more careful consideration in design to give close control of process temperature, protection of coils against rain and hail, and controlled recirculation of warm air to avoid freezing of high-melting point fluids. Supplementary evaporative cooling will allow the air cooled exchanger to compete with outlet process temperatures from water cooled exchangers for many applications.

Extended surface for high temperature. More technical data is needed on various types of extended surface to allow the proper selection of these finned tubes for process fluids at higher temperatures.

Maintenance and cleaning. Easier methods of cleaning the tubes on the process side are required for some chemical applications. Methods of protecting the extended surface to provide greater corrosion resistance are needed for many chemical plant atmospheres.

Sound control. The noise from propeller fans can become an industrial nuisance if careful consideration is not given to sound control in the air cooled exchanger design.

Advantages of air cooling

While considerable "know-how" must be developed before air cooling will substantially replace water cooling in chemical plants, the numerous advantages of air cooled exchangers should provide the incentive for further development. The following are some advantages of air cooling:

Even where water is plentiful, lower plant investment and operating cost can often be attained through the use of air cooled exchangers. Reduced investment cost is realized mainly in water supply and disposal facilities. Operating savings are realized through less maintenance of equipment, improved continuity of operation, and the usually inherently lower cost of utilizing air instead of water.

While removing waste heat, the air cooler can also be used to supply building heating during cold weather periods, thus reducing boiler plant capacity.

The use of air for high temperature cooling greatly reduces troublesome and expensive maintenance problems where water is in contact with hot metal tubes.

Air cooling offers important long-term advantages. It permits greater latitude in expansion of existing facilities or selection of new plant sites. Air cooling will assist in the long-term planning to meet the trend of State and Municipal restrictions on the use of water.

The development of air cooled exchangers, with supplementary evaporative cooling during hot weather periods, may provide outlet process temperatures for many locations equivalent to water cooled exchangers.

The use of air coolers helps preserve investment that might otherwise be jeopardized in areas of growing water scarcity. Where there is critical competition for an area's water supply, air cooling may assist in maintaining good public relations.

Condensed from a paper, presented at the A.I.Ch.E. Annual Meeting in Cincinnati.

metal finishing Waste reduction

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Metal-finishing operations, such as plating, anodizing, and bright-dipping, frequently produce large quantities of water-borne wastes. The most significant wastes are those produced in the very-thorough cleaning operations which precede the finishing step and in the rinsing operations after finishing. The wastes are likely to contain materials such as copper, zinc, chromium, cyanide and organic materials which interfere with the biological processes occuring in natural waterways or in sewage disposal plants.

Since water has been one of our cheapest commodities the general attitude towards its use in the metal finishing industries has been that of using copious quantities of water to insure that the desired finish is not harmed by residual cleaning agents or finishing solutions. This attitude has been modified somewhat in the past few years as pollution control became necessary in many parts of the country. The cost of treating wastes frequently amounts to several times the original cost of the water, so that the incentive to reduce water usage becomes more intensive. There is little question but that the requirements for pollution control will become even stricter in the future. Furthermore, there are numerous areas in the country which can reasonably expect the cost of water to rise in the next few years. Thus in the next few years there is certain to be more incentive for all industries to minimize water usage.

These facts have long been recognized by some groups (*1*) and by numerous individuals. Although methods of reducing water usage are discussed in several papers and have been used in many plants, it is difficult to persuade the proper persons that these methods have merit. But thinking will change as proper information is made available (*2*).

One of the characteristics of literature published on the subject of waste reduction by good housekeeping is its qualitative nature. This is the only way that some of the factors can be discussed, but there are others which can be discussed from a quantitative point of view. The operator, designer, or supervisor of metal finishing equipment is interested in knowing, for example, that the water usage in a continuous rinsing operation can be reduced by the use of a countercurrent system, and how much it can be reduced. In fact, this information must be available to provide a basis for deciding whether the resulting decrease in water costs and pollution control costs is sufficient to justify the added expense of the countercurrent system.

This article is an initial attempt to bring together the quantitative data and methods that have been published on some of the available water-saving and waste-reduction methods. It will be apparent that there are many areas where more information is needed. It is hoped that some of the missing information will be developed in an experimental program now being planned.*

* *At Yale Univ., Dept. of Ch. E., sponsored by Conn. State Water Resources Comm.*

The waste survey

The term "good housekeeping" refers to any physical feature of operation or design of metal-finishing equipment which may be involved in water-saving or waste-reduction. Good housekeeping begins with an accurate knowledge of the flow rates and compositions of waste streams. Time devoted to gaining a clear picture of the compositions and volumes of waste streams, either in an existing plant or in a projected plant, will be time well spent. In an existing plant the only reliable information of this type, is that gained by actual experimental determination of flow rates and liquid compositions. Subjective reactions are likely to be quite unreliable. Visual observation of the wastes entering a waterway in dilute rinse streams cannot be made, yet in some cases these streams may contribute more to the pollution load than do dumpings. Obtaining the necessary data (*3*) is a tedious job of determining flow rates (metering water to individual units, draining a process tank and noting time required for it to fill, using wiers in appropriate places, etc.), using dyes to trace lines, and chemical analyses of solutions whose compositions may vary by a factor of ten, or more, over a period of time. A detailed account of such a survey in an electroplating plant has been published (*4*).

The knowledge gained from such surveys is useful in planning a drainage system. In a complex plant, drain lines for the following classifications

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of industrial wastes might be involved:

1. Clean wastes.
2. Wastes to be treated.
   a. Acid wastes; from scale removal or plating operations, consist of mineral acids contaning salts of metals such as Cu, Ni, Zn, Cr and Fe.
   b. Alkaline wastes; from phosphate, caustic, and silicate cleaners; from alkalis used as plating-bath ingredients, and from metal cyanides.
   c. Wastes bearing organic materials; as soaps, oils, grease, and lacquers.
   d. Wastes bearing recoverable materials.

In some cases, some or all of the wastes from a plant may be acceptable directly into a waterway or a municipal sewer system provided that peaks in flow rates or compositions are avoided by equalizing. In one complex electroplating plant 75% of the liquid waste could be sent directly to a receiving stream (*4*). The data of a waste survey are likely to be the only kind of results convincing to the members of regulatory agencies when this possibility is being explored (*5*).

Still other possibilities which might become apparent in a waste survey are those of using one waste stream to treat another, using acid wastes to neutralize alkali wastes, or using the floc formed by neutralizing acid wastes containing copper, zinc, and other heavy metals to clarify other wastes (*6*).

Process layout

A second feature of good housekeeping for metal finishing operations is the physical layout of equipment and drains. In addition to providing for appropriate segregation of clean wastes and wastes to be treated, the physical layout must be planned to minimize the possibility of accidents which might result in gross pollution of a waterway or a municipal sewer. Only a few general features of such layouts are noted here. More specific information may be found in other sources (*7, 8*).

Floor drains must be routed to some line other than that bearing clean wastes. There is always the possibility that some of the floor drains may be required to carry the liquid from a tank failure or spill. These drains may be routed to an emergency tank, directly to a treatment plant (if such exists), or to a lagoon area.

Some of the tank drains must be designed to insure against drainage into the clean waste lines or *siphoning* into water supply lines. Inlet water should not be supplied by an interrupted line leading to a submerged discharge. It is advisable to provide for running rinses to be removed at the top of a tank, even though this might mean (for occasional clean-outs) that complete drainage of the tank can be accomplished only by putting in a temporary line or hose reaching to the bottom of the tank. The use of non-breakable containers should be practiced where-ever possible.

Draining and rinsing operations

Perhaps the greatest opportunities for water saving and waste reduction in the metal-finishing industries lie in continued improvement of the draining and rinsing steps. It should be noted that the ultimate load of contaminants to be removed from a metals-finishing plant is determined by process considerations. Thus in *scale removal* the amount of metal in waste acid streams is determined by the amount of oxide scale from annealing; in *cleaning baths* the exhaustion of reagent, or interference by materials removed from the work (such as oil) make it necessary to dump a tank; the accumulation of impurities in *plating baths* may ultimately lead to replacement. The objective of the methods listed here is not to reduce the ultimate load of contaminants but to contain them in as small a volume as may be practicable, in some cases making their re-use possible.

Quantity of Dragout (amount of solution adhering to the work being processed as it leaves a solution), which occurs in a given application is determined by process factors such as the shape of the work and the properties of the solution. Since it is usually possible to reduce the quantity of dragout only by process changes, opportunities for waste reduction by dragout are limited. A few quantitative studies of dragout have been made (*9-12*).

Studies made of dragout when thin plates and fine wires are removed at slow speeds (less than 0.3 ft./sec.) from solutions, and other studies indicate that the thickness of the film adhering to thin plates is:

1. Proportional to the ½ to ⅔ power of the velocity.
2. Proportional to the ½ to ⅔ power of liquid viscosity.
3. Inversely proportional to the square root of liquid density.

Although surface tension forces were found to be important for very fine wires (9) most applications can probably be handled by consideration of the gravitational-viscosity forces only.

Quantity of Carry-Over (amount of solution adhering to work as it arrives at a subsequent unit, Figure 1) is subject to reduction by proper design, which is not the case with dragout. Carry-over as used here is dragout *minus* the amount of liquid removed (by drainage or other means) before the work reaches a subsequent unit. The draining process might be improved by using air wipers, a shaking mechanism, or simply by allowing a longer drainage time, Figure 2.

The degree of reduction in carry-over which can be accomplished is highly variable, depending on the nature of the work. The literature reports a plating shop in which carry-over of a cyanide solution was reduced about 25% by increasing the drain time over the plating bath by 1

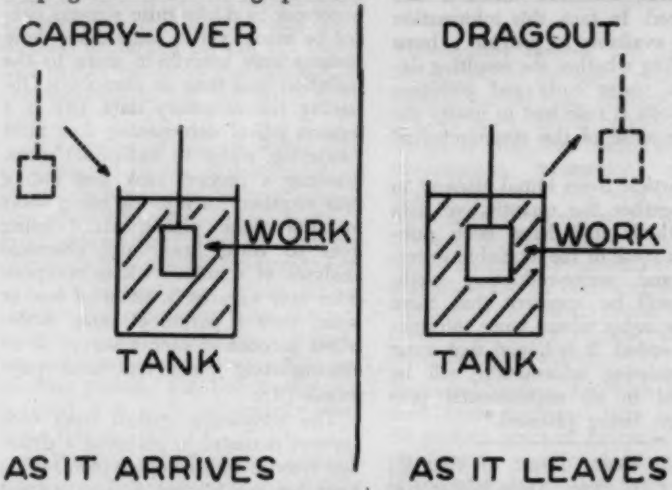

Figure 1. Adhering solutions.

minute (*13*). The carry-over was further reduced about the same amount by allowing the dripping to continue over the next unit in the line. In another reported case (*14*) the carry-over of a chromium plating solution was reduced 60% by the use of a drip rack above the plating bath. In still another case the use of air wipers (*15*) removed 75% of the adhering solution,

Generalized evaluations (*11, 12, 16*) of the effect of drainage time have shown that the amount of liquid adhering to a thin rectangular plate was inversely proportional to the square root of the time. With other shapes the effect of time is less marked (*16*). Although little work has been done with other shapes, a qualitative estimate of the effect of physical properties of the solution and geometrical shapes on carry-over has been made (*17*). The quantitative effect of shape has been reported (*11*) for vertical and horizontal surfaces and for well-drained and poorly-drained cuplike surfaces. The range of carry-over was reported to be from 0.0004 gal./sq. ft. for a vertical well-drained shape to 0.0240 gal./sq. ft. for a poorly drained cuplike surface.

Degree of rinsing required and control of water usage. There is no doubt that many rinse rates are far above the actual minimum required. In one reference (*18*) flow rates of running rinses in plating rooms were reduced ten-fold without impairing results. There are at least two general methods for determining the minimum rinsing requirements in an existing plant. The first is a trial and error method to determine the rinse rate at which product quality is barely acceptable. The second (also applicable for the design of a new plant) is a computational method based on:

1. **Allowable impurities** on the finished work; thus the allowable solid concentration in solutions adhering to the finished work.
2. **Minimum water requirements** to prevent impurities from rising above allowable levels, after accounting for the degree of mixing in the rinses.

After the minimum rinse requirements have been determined, the actual rinse rates to be used, including a safety factor, may be determined from a cost analysis. A general figure for the allowable concentrations of solids in the solutions adhering to finished work cannot be given because of the marked differences in the tendency of solids to stain, or otherwise mar surface finishes. In general practice (*19, 20*) the limits are probably in the range of 40 to 750 mg./liter (40 to 750 ppm, or 0.005 to 0.1 oz./gal.).

Despite the difficulty of arriving at a satisfactory figure for the acceptable minimum degree of rinsing it is necessary that some goal be set, even though it may be far above the minimum. After this goal is set it is essential that adequate controls over water usage be established and maintained.

The operator of equipment is charged primarily with controlling the quantity and quality of finish produced in his department. His interest and efforts in control of water usage will be secondary to his main work and can become effective only if an extensive and continuing campaign of employee education is in effect. Use of automatic controls (*18, 19*) can relate water flow to the flow of work through the equipment, providing at least for shutting off the water when no work is being processed.

The still rinse

The actual rinsing operation begins after the removal of adhering solution by simple drainage or air wiping. Use of a still rinse before the running rinses offers the following possible advantages:

1. The solution in the still rinse tank might be useful for make-up in the preceding process tank. The still rinse will be considerably more dilute than the solution in the preceding tank. If evaporation losses from the process tank are high, the still rinse might be used directly for make-up; otherwise, a concentration step such as evaporation might be required.
2. The still rinse is sometimes so effective that the concentration of contaminants in subsequent running rinses is reduced to the point where these can be considered to be clean water.

The degree of removal will vary markedly from case to case, depending on the shape of the work and on the frequency of replacing the water in the still rinse tank.

Quantitative analysis of the effectiveness of still rinses. Consider a still rinse tank which is filled initially to a constant level with water containing no undesirable impurities; that work from a process tank is dipped in the still rinse tank for a period of time and then removed; and that each such dipping and removal is one cycle.

Let: F = rate at which liquid is carried over from the process tank to the still rinse tank by adhering to the work (gal./cycle).

D = rate at which liquid is removed from the still rinse by adhering to the work (gal./cycle).

C_p = impurity concentration of the liquid carry-over (F) from the process tank (oz./gal.).

n = number of cycles which have occured (cycles).

C_n = impurity concentration in the rinse tank after n cycles have occured (oz./gal.)

f_R = fraction retained

V = initial rinse tank volume (gal.).

If the rate of liquid carry-over is assumed constant and equal to rate of liquid removed, then $F = D$. Furthermore, if it is assumed that *complete* mixing occurs before the work is removed from the still rinse, then at the time of removal, the impurity concentration in the rinse tank is constant

continued

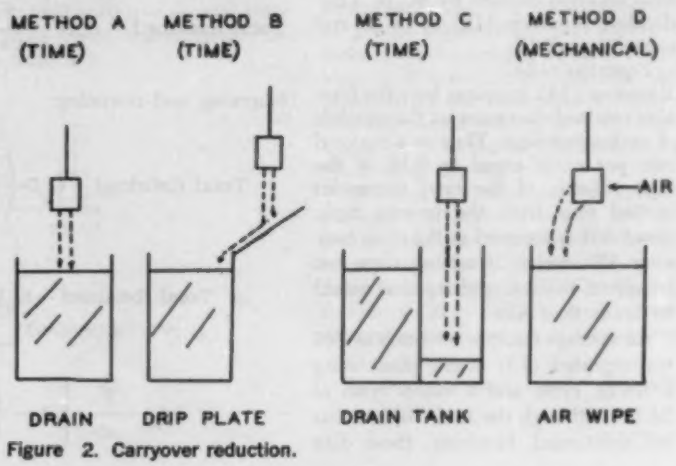

Figure 2. Carryover reduction.

Waste reduction

continued

throughout the tank and is the same as the impurity concentration of the liquid being removed by dragout. Since $C_0 = 0$, the material balances for 1, 2, and n cycles are respectively:

Equations (1) through (5).

$$C_1 = \frac{C_p D + V C_0}{V + D} = \frac{C_p D}{V + D} \quad (1)$$

$$C_2 = \frac{C_p D + C_1 V}{V + D} = \frac{C_p D}{V + D}\left(1 + \frac{V}{V + D}\right) \quad (2)$$

$$C_n = \frac{C_p D}{V + D}\left[1 + \left(\frac{V}{V + D}\right) + \left(\frac{V}{V + D}\right)^2 + \dots + \left(\frac{V}{V + D}\right)^{n-1}\right] \quad (3)$$

Summing the sequence and rewriting:

$$C_n = \frac{C_p D}{V + D}\left(\frac{V + D}{D}\right)\left[1 - \left(\frac{V}{V + D}\right)^n\right] \quad (4)$$

$$\text{or} \quad \frac{C_n}{C_p} = 1 - \left(\frac{V}{V + D}\right)^n \quad (5)$$

From Equation (5) it can be shown that in 350 dipping cycles (such as 50 cycles per hour for 7 hours) at a liquid removal rate per cycle of 0.1% of the tank volume (or D/V = 0.001 per cycle), the tank concentration would build up to 30% of the process tank concentration. Note that when the number of cycles becomes very large, the tank concentration approaches the carry-over concentration. For this reason, **still rinses are not run until steady state is reached,** but are dumped at the proper time. Note also that if mixing were not complete, the tank concentration after 350 cycles would be less than 30% of the carry-over concentration.

Another characteristic of the still rinse which is required for proper design is the fraction of the total impurities carried over from the process tank which is retained in the rinse tank after n cycles. Let L_n be the amount, in ounces, of the accumulation of the impurities in the rinse tank during the nth cycle. Since by material balance, accumulation equals the amount **in** minus the amount **out,** the amount left in the tank after the first cycle is:

Equations (6) through (9).

$$L_1 = C_p D - C_1 D \quad (6)$$

Substituting for C_1 by Equation (1):

$$L_1 = C_p D\left(\frac{V}{V + D}\right) \quad (7)$$

For the second and nth cycle:

$$L_2 = C_p D - C_2 D = C_p D\left(\frac{V}{V + D}\right)^2 \quad (8)$$

$$L_n = C_p D\left(\frac{V}{V + D}\right)^n \quad (9)$$

The total amount retained at n cycles is equal to sum of all the L's up to L_n

Equations (10) through (12).

$$\text{Total Retained} = C_p D\left[\frac{V}{V + D}\right]\left[1 + \left(\frac{V}{V + D}\right) + \dots + \left(\frac{V}{V + D}\right)^n\right] \quad (10)$$

Summing and rewriting:

$$\text{Total Retained} = C_p D\left(\frac{V}{V + D}\right)\left(\frac{V + D}{D}\right)\left[1 - \left(\frac{V}{V + D}\right)^n\right] \quad (11)$$

$$\text{or Total Retained} = C_p V\left[1 - \left(\frac{V}{V + D}\right)^n\right] \quad (12)$$

Since the total amount carried over from the process tank in n cycles is nC_pD, the **fraction retained,** f_R, is the total retained divided by nC_pD. Thus dividing Equation (12) by nC_pD and cancelling out C_p:

Equation (13).

$$f_R = \frac{V}{nD}\left[1 - \left(\frac{V}{V + D}\right)^n\right] \quad (13)$$

Equation (13) indicates how the fraction retained decreases as the number of cycles increases. Thus at a removal rate per cycle equal to 0.1% of the tank volume, of the total impurities carried over from the process tank, about 83% is retained in the rinse tank after 350 cycles. If mixing were not complete, the retained fraction would be lower than 83%.

An average fraction retention of 74% was reported (*13*) at one plant using a 1-min. cycle and a dump cycle of 24 hr., although the tank volume was not mentioned. However, these data

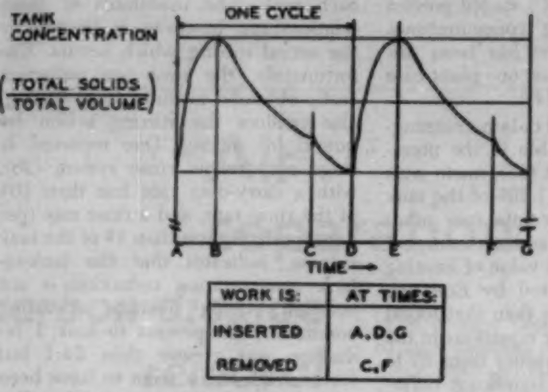

Figure 3. Running rinse concentration.

are not comparable to Equations (5) and (13), as the rate of carry-over entering the rinse was much less than the removal rate (or $F = 0.25\ D$) and thus the tank volume was not constant.

Equations (5) and (13) were developed by assuming complete mixing. However, one reported experiment (*16*) indicated that good mixing had not been obtained 2-½ min. after a basket of work had been placed in a still-rinse tank. Nevertheless, good mixing is desirable so that the still rinse concentration will build up to the desired levels for evaporation and use or for treatment; and so that treatment of rinses following the still-rinse tank will be minimized. Therefore it may be necessary to agitate still-rinse tanks by air or mechanical means to obtain the most efficient impurity removal.

Running rinse

The running rinse operation is similar to still rinse operation with one important exception; the running rinse is continuously fed with water while water is drawn off continuously at the same rate. However, because of this continuing flow, the tank concentration is constantly being diluted, except when the liquid carry-over from a fresh batch of work is mixing with the tank water. As a result of this dilution effect, the tank concentration will reach, at a **pseudo-steady state,** a limiting concentration level below that of the incoming carry-over concentration. This limiting level permits continuous operation, or operation without periodic dumpings. Note, however, that from the standpoint of the tank concentration, the running rinse is not continuous and does not reach steady state, for it is regularly subjected to jolts of highly concentrated solution in the form of carry-over. Because of the stagewise nature of this rinse, the tank concentration periodically rises when the carry-over is added, and then decreases until the next carry-over arrives.

Although tank concentration in a running rinse varies periodically and although the average concentration per cycle generally increases with time, after a sufficient time, *tank concentrations* will form repeated, identical cycles. When this time is reached, pseudo-steady state and limiting concentrations will have been attained. These limiting concentrations, vary throughout each cycle. Figure 3.

There are at least two general viewpoints from which the running rinse may be analyzed:

1. Maintaining impurities on the finished work below a specified level.
2. Maintaining outlet rinse concentrations at specified levels at pseudo-steady state.

The first viewpoint satisfies the need for rinsing. The second viewpoint is often used because it is easier to measure. It should be noted that there are several outlet rinse concentrations which may be used: **maximum,** which occurs shortly after the work is dipped; **minimum,** which occurs just before work is dipped; and **average** concentration during a complete dipping cycle. The maximum rinse concentration may be the one useful for designing waste treatment, but where effluent holding volume is available, the average rinse concentration is often more useful.

Most investigators (*21, 22*) have related the two viewpoints for analyzing rinses by using the simplifying assumption that, at the instant the work is submerged, mixing takes place instantaneously and completely. Thus, at any time, the solid concentration of the liquid adhering to the removed work is always equal to the tank concentration. If mixing is not complete and instantaneous, the concentration on the work will always be higher than the tank concentration. In addition, if mixing is not complete, the outlet rinse concentration may be higher or lower than the average tank concentration.

The first design consideration is the **dilution rate curve** which occurs after carry-over has mixed with the tank. With perfect mixing, an exponential fall-off curve is predictable. With a rinse rate per minute which was 10% of the tank size, one set of experimental results (*23*) show an exponential curve, although some of the predicted concentrations are as much as 25% higher than the measured concentrations. The very good agreement of recent experiments (*16*), using a ratio of rinse rates per minute to tank size of 0.9 and 1.4%, indicate that good mixing can be maintained in the dilution part of the cycle, if the rinse water enters at the tank bottom and is removed at the top.

The second design consideration is the effect of both increasing and decreasing tank concentrations. Although several equations for running rinses have been proposed (*20, 21, 22, 24*), for brevity only one (*22*) will be considered here. Three major assumptions were made:

1. Instantaneous and complete mixing.

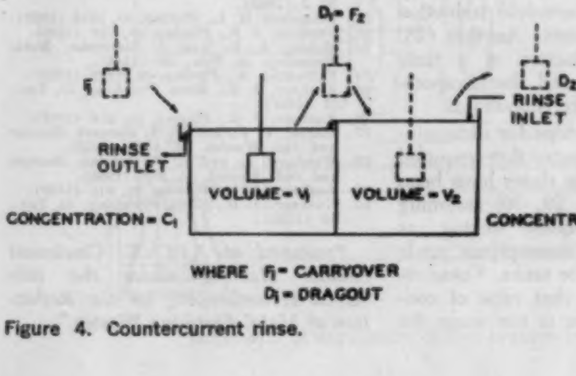

Figure 4. Countercurrent rinse.

continued

Waste reduction

continued

2. Negligible carry-over rate (per minute) with respect to tank volume.
3. Small, but not negligible, rinse rate (per minute) with respect to tank volume.

The second and third assumptions were made to simplify a more complicated expression, which was presented. The second assumption is actually more stringent than the third and can be expressed mathematically as:

$$1 - \frac{D}{V} \simeq 1 \qquad (14)$$

The third assumption is used to justify the substitution:

$$e^{-R/V} \simeq 1 - \frac{R}{V} \qquad (15)$$

where R is the rinse rate (gal./min.).

The following other assumptions are either made or implied: the production is uninterrupted and is dipped at periodic intervals; the rinse flow is shut off when operation is terminated; the carry-over rate is the same as the dragout rate and both have negligible variations; evaporation loss is negligible; and the flow of rinse water from the rinse tank is not reduced or stopped at the time of dragout. Using the above assumptions and the algebra of staged operation, the following equation for the limiting concentration was derived, at pseudo-steady state by the use of infinite series:

$$\frac{C_L}{C_P} = \frac{D}{pR}\left(1 - \frac{pR}{V}\right) \qquad (16)$$

where p is the length of time between dippings (min.) and C_L is the minimum limiting concentration (oz./gal.) (the limiting concentration just before a dip).

Some discussion *(24)* has appeared concerning the presence of the V-term for tank volume in Equation (16), since an equation can be derived *(16, 20)* by the use of a simple material balance at "equilibrium" which indicates that the limiting concentration is independent of tank volume. The error in using these simple material balances, which may be small in some cases, stems from the incorrect assumption of continuous operation, rather than the use of a staged process involving fluctuating concentrations. The effect of volume has been discussed (25) and at least one plant case has been reported *(14)*.

Some experimental data on running-rinse runs are available in the literature. One experiment *(23)*, made with a rinse rate (per min.) 10% of the tank volume, a carry-over rate (per min.) 1% of the rinse rate and zero dragout rate, showed that the value of limiting concentration predicted by Equation (16) was 20% higher than that found by experiment. Other equations in the literature predicted values from 25 to 40% high *(26)*. This significant difference is attributed by us to be due primarily to the failure of the mixing assumption to apply here. Another experiment *(16)* indicates that over 100 sec. are required for fairly good mixing where the rinse rate per min. is 3% of the tank volume.

This failure is probably the most important inaccuracy in literature equations, for if the actual limiting tank concentrations are lower than predicted, the concentration in the dragout is higher than the predicted value by an appreciable amount. Thus the concentration on the work being removed, may be considerably above the predicted values, and perhaps, also above the maximum allowable impurity level. Further experimental measurements should be made to clarify the degree of mixing and to measure the actual dragout concentrations.

It should be noted that other equations are given in the literature for cases of high dragout and rinse rates (20) and for cases where dragout is large enough to slow down the rate of rinse water leaving the rinse tank during part of the cycle *(21)*.

Countercurrent rinsing

Where space is available, several running rinses, with water flowing countercurrent to the work, have been used in series to reduce water usage and to concentrate the carry-over material. (Figure 4.) One case history *(27)* reported a fifteen-fold reduction in water requirements. Another *(28)* reported the production of a rinse stream so concentrated that evaporation and re-use were economical.

General relationships for determining the minimum water flow required for these multi-stage rinses have been developed *(21, 25, 29, 30)* assuming instantaneous, complete mixing, as well as the other assumptions made for single-stage rinse tanks. These relationships predict that ratio of concentration-reduction is the same for each tank. The usefulness of these relationships, however, is limited by the actual mixing which occurs. Unfortunately, the rinse-rate reduction easily obtained in multi-stage rinsing, also reduces the stirring action required for mixing. One reported 4-stage counterflow rinse system (28), with a carry-over rate less than 10% of the rinse rate, and a rinse rate (per min.) probably less than 1% of the tank volume, indicates that the tank-to-tank concentration reduction is not constant. Using average operating conditions, the process to tank 1 reduction was greater than 24:1 but further reductions seem to have been 14:1, 8:1, and 4:1, respectively. This indication of poor mixing, especially in the last, dilute tanks, is noteworthy, since the rinse flow rates predicted from ideal mixing may actually be lower than those actually required if poor mixing is present. Mixing could be improved, however, by air or mechanical agitation.

LITERATURE CITED

1. Ohio River Valley Water Sanitation Comm., (414 Walnut St., Cincinnati 2, O.), "Plating Room Controls for Pollution Abatement" (1951).
2. Wisniewski, T. F., *Plating*, *43*, 494 (1956).
3. Ohio River Valley Water Sanitation Comm., "Planning and Making Industrial Waste Surveys" (1952).
4. Walker, C. A., and P. W. Eichenlaub, *Sewage and Ind. Wastes*, *26*, 848 (1954).
5. Swartz, C. J., *Sewage and Ind. Wastes*, *26*, 1468 (1954).
6. Walker, C. A., W. Zabban, R. W. Southworth and E. P. Heslin, *Sewage and Ind. Wastes*, *26*, 840 (1954).
7. Stadel, W. E., *Plating*, *38*, 939 (1951).
8. Poole, B. A., R. H. Holtje and W. G. Better, *Sewage and Ind. Wastes*, *26*, 1382 (1954).
9. Goucher, F. S., and H. Ward, *Phil. Mag.*, 6th Ser., *44*, 1002 (1922).
10. Morey, F. C., *J. Res. Bur. of Stds.*, *25*, 385 (1940).
11. Soderberg, G., *Tech. Proc. Am. Electroplaters' Soc.*, *24*, 233 (1936).
12. Kushner, J. B., *Metal Finishing*, *49*, Nov., 59 (1951).
13. Mauri, C. F., *Sewage and Ind. Wastes*, *25*, 586 (1953).
14. Pinner, W. L., *Sewage and Ind. Wastes*, *24*, 1482 (1952).
15. Keller, F. R., C. C. Cupps and R. E. Shaw, *Sewage and Ind. Wastes*, *24*, 202 (1952).
16. Mohler, J. B., *Plating*, *43*, 782 (1956).
17. Kushner, J. B., *Metal Finishing*, *49*, Dec. 58 (1951).
18. Miller, W. B., and V. deP. Lukas, *Sewage and Ind. Wastes*, *26*, 1475 (1954).
19. Mohler, J. B., *Metal Finishing*, *53*, Sept., 66 (1955).
20. Kushner, J. B., Sect. on rinsing techniques in "Metal Finishing Guidebook", 26th Ed. (Finishing Publications, Inc., Westwood, N. J., 1958).
21. Pinkerton, H. L., *Plating*, *39*, 1016 (1952).
22. Kushner, J. B., *Plating*, *36*, 798 (1949).
23. Mohler, J. B., and J. Sternisha, *Metal Finishing*, *44*, Feb., 58 (1946).
24. McDonald, N., *Plating*, *36*, 1202 (1949).
25. Kushner, J. B., *Metal Finishing*, *47*, Dec., 52 (1949).
26. Kushner, J. B., *Plating*, *40*, 616 (1953).
27. Hendel, F. J., and V. T. Stewart, *Sewage and Ind. Wastes*, *25*, 1323 (1953).
28. Weisberg, L. and E. J. Quinlan, *Sewage and Ind. Wastes*, *28*, 998 (1956).
29. Kushner, J. B., *Plating*, *36*, 915 (1949).
30. Kushner, J. B., *Metal Finishing*, *50*, Jan., 60 (1952).

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Air separation

carbon dioxide removal by adsorption

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The process described is applicable to air-separation plants using conventional shell-and-tube heat exchangers. In two ways it meets the demands of today for removing carbon dioxide: first, it eliminates caustic scrubbing (which until recently was the normal method of removing carbon dioxide from the air to be separated in air-separation plants using conventional, continuously operating shell-and-tube heat exchangers); second, it offers the highest degree of safety for air-separation plants as far as dangerous accumulations of hydrocarbons in the cold box are concerned.

Both improvements are realized by this removal, just above the dew point, of the carbon dioxide, and also the hydrocarbons such as acetylene by means of adsorption, for example, with silica gel. Two interchangeable adsorbers are used. Before the adsorber in use is exhausted, it is exchanged for one that is freshly regenerated, regeneration being effected by allowing a gas which is free of CO_2 to flow through the adsorber. This may be done at the temperature of adsorption, or by simultaneously warming up the adsorber to ambient temperature.

Application of process

The practical application of this process in a medium-pressure air-separation plant is described in Figure 1. Air is compressed to about 14-18 kg./sq. cm. (200-250 lb./sq. in.), during summer months 16-20 kg./sq. cm. (225-280 lb./sq. in.), and then dried in interchangeable activated alumina adsorbers. The dried air is then cooled down in the exchangers *A, B,* and *C* to nearly the

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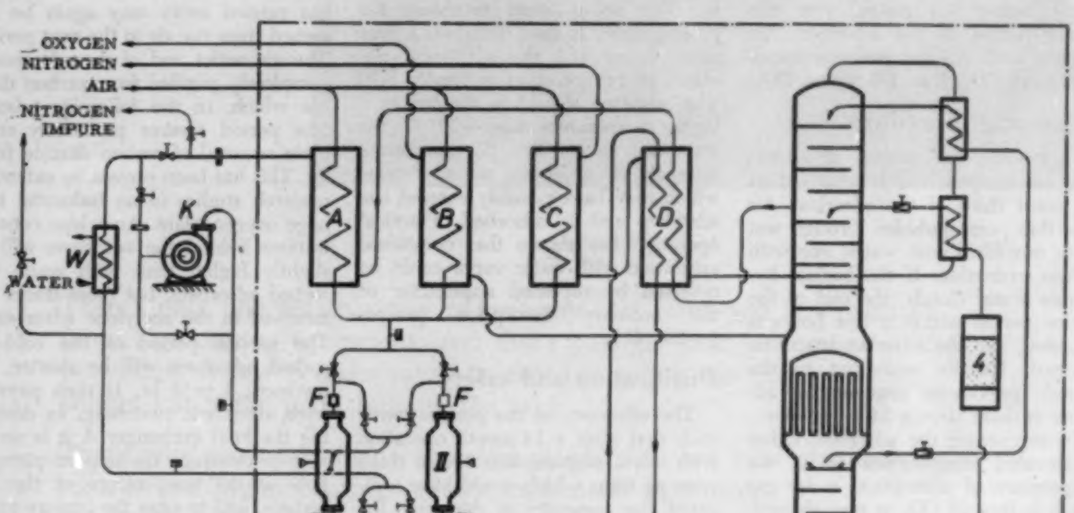


Schematic of application of this process in a medium-pressure air separation plant.

dew point of the carbon dioxide, against the separation products—impure nitrogen, pure oxygen, and pure nitrogen. After this, carbon dioxide and hydrocarbons (for instance, acetylene) are removed in the interchangeable silica gel adsorbers I and II. A part of the air so purified is expanded in the expansion engine *E* in the performance of work, the rest is liquefied in exchanger *D* in exchange with pure and impure nitrogen. Then it is expanded in the expansion valve 1 into the pressure column 2. The exhaust of the expansion engine enters the pressure column at the low end at 3. The air is separated in a two-stage rectification and the separation products are warmed up in the usual way. For safety's sake the acetylene adsorber 4 was not eliminated in the first plant.

The CO_2 adsorbers are cylindrical vessels with reducers at the ends for smaller flanges made of stainless steel, the wall thickness being designed to withstand the start-up pressure of 50 atm. (700 lb./sq. in.). They are solidly packed with silica gel. Filters *F* prevent gel dust from reaching the expansion engine or the expansion valve. The adsorber is sized to keep the CO_2 content of the purified air mostly below 0.5 p.p.m. over the service period of the adsorber. Air purified with caustic contains somewhat more CO_2, i. e., 1-3 p.p.m. CO_2.

Processing procedure

To monitor the process of saturation, an analysis line is attached at the lower third of the adsorber. Air from this point bubbles through test tubes, one filled with water, one with barium hydroxide. If the barium hydroxide water clouds, the end of the service period within a few hours is indicated, and the adsorber has to be changed. Usually switching to the second, previously regenerated adsorber is done after a 24-hr. service.

To regenerate the adsorber, either at elevated temperature or at the temperature of adsorption, a dry gas which is free of CO_2 is sent through the adsorber. Since nitrogen and oxygen as main products are not available, only the impure nitrogen fraction can be used in the plant described here.

This fraction is too small to warm up the valves, the gel filling, and the vessels of the adsorbers from operating to ambient temperature if used only once. Therefore, the recycle blower *K* is used which sucks cold regenerating gas from the adsorber through the heater *W* and feeds it back to the adsorber at a temperature of 20 to 40° C. The cycle is continuously "flushed" with the impure nitrogen fraction. The cycle warms up the adsorber system and desorbs the carbon dioxide. In 24 hr., 18 cu. ft. CO_2 are adsorbed from 1250 std. cu. ft./min. of air.

The cycle contains:

at −51 °C. after 1.25 hr. 8% CO_2
−18 °C. after 2 hr. 0.8% CO_2
and +20 °C. after 3 hr. 0.1% CO_2.

In order to remove CO_2 completely from the adsorber, especially from the end at the outlet, the blower is stopped in the last phase, and, for one hour, only the fraction of impure nitrogen, which is free of CO_2, is fed to the adsorber at a temperature of +20° C.

To cool down the adsorber to the operating temperature 15 to 18 hr. are now still available. The outlet valve is opened and a small flow of precooled air then flows parallel to the adsorber in operation and cools down the adsorber just regenerated. This small partial side stream is freed of CO_2 by the comparatively large amount of gel. Downstream of the adsorber it joins the main stream. The cooling-down is completed after about 10 hr., regeneration and cooling-down together taking about 15 hr. The refrigeration necessary for cooling-down is thus distributed over many hours and the additional demand of refrigeration is hardly felt. The adsorber should be heated to a higher temperature than +20° C., for instance, to +100° C. in longer intervals in order to remove water which may have possibly entered the adsorber and is adsorbed. Practical operation has shown that occasional saturation with water vapor could be reversed by repeated application of the ordinary desorption process (+20° C.).

Purification and safety

The efficiency of the purification is such that after a 14-month operation with warm regeneration circuit there were no signs which would have indicated the necessity of deriming the plant.

In the CO_2 adsorbers, hydrocarbons such as acetylene are also retained down to a small fraction of their initial concentration, even under severe conditions. There are two reasons for this excellent purification effect of the warm-desorbed adsorbers: first, carbon dioxide is present in air in far higher concentration than hydrocarbons. The adsorbers are sized for the carbon dioxide and desorbed daily, i. e., after a comparatively short period. Second, the silica gel adsorbs, for instance, acetylene much more than carbon dioxide. Acetylene even displaces carbon dioxide from gel with the result that the adsorbers are of tremendous size if one considers only acetylene. The same is true for hydrocarbons of higher molecular weight, alcohols, ketones, and similar compounds. The conditions are almost the same for C_4, C_3, and C_2 hydrocarbons, but not for methane. However, methane is comparatively harmless in an air-separation plant. NO together with its product of oxidation NO_2 is also retained in the adsorber. It is probably safe to say that no system of air separation for the production of gaseous oxygen has a higher degree of safety against damaging effects of air pollution, than the system described here. The degree of safety is at least the same as in liquid-oxygen-producing plants.

It would be possible to regenerate the adsorber without additional cold loss, and projected plant modifications will make use of this step. For this purpose the cold, impure nitrogen fraction will be sent through the saturated, cold adsorber in the opposite direction to the air. The gas picks up carbon dioxide from the silica gel. As much carbon dioxide as the gas has carried away may again be adsorbed from the air in the next period. The air outlet end of the adsorber is completely purified from carbon dioxide which, in the following adsorption period assures practically complete removal of carbon dioxide from air. This has been proven by extended research studies in an industrial tonnage oxygen plant. Acetylene concentrations behind the adsorbers will be slightly higher than with warm desorbed adsorbers, but these traces are removed in the acetylene adsorber 4. The service period of the cold-desorbed adsorbers will be shorter, for instance, 3 to 4 hr. It then pays to have automatic switching. In designing the heat exchanger *A* it is necessary to interrupt the impure nitrogen flow at the temperature of the adsorbers, and to pipe the impure nitrogen to the adsorber and back to heat exchanger *A*, where the nitrogen-carbon dioxide mixture is further warmed up to ambient temperature. The blower-circuit *K* is then omitted. Automatic switching frees operators from changing the adsorbers. This should be of greater importance than saving the small cold losses involved with warm desorbing. # #

industrial news

A five year option on lithium mining properties in North Carolina has been granted to Texas Gulf Sulphur Co., under an agreement with Basic Atomics, Inc. Also included is a five-year option on patent rights on a new process for the recovery of lithium from spodumene bearing ores and concentrates. Texas Gulf will initiate further investigation and study of the properties and process.

The thermodynamic properties of pure sulfur have been accurately determined. Achievement was made by the use of a newly developed method of purifying sulfur to 99.999 mole percent, and a recently designed adiabatic calorimeter for measuring heat quantity at high temperatures. Previously, accruate data has been limited because of the difficulties in purifying sulfur. Accurate calorimetric measurements of pure sulfur are particularly important in predicting equilibria of chemical reactions in petroleum refining. Work was done by the National Bureau of Standards, in a program partly supported by Allied Chemical and Dye, and API.

Said to be the first computer-operated control system for continuous processing, a successful pilot plant operation has resulted from joint effort by Daystrom, Inc., and Universal Oil Products Co. It is expected to broaden applications for continuous processes by controlling operations too complex for previously available systems.

A sulfuric acid plant in Paulsboro, N. J., is the first unit in an expansion program undertaken by Dixon Chemicals. The $5 million investment, will, it is said, be one of the world's largest when completed late this year. Situated on a 70-acre site, the 300,000 ton a year facility is part of Dixon's planned five year program which will transform the entire area into a chemical producing works.

An active alumina in the form of spheres is now being manufactured by Kaiser Aluminum. The spheres, in various sizes with diameters from ⅛ to ½ inch, possess high abrasion resistance and the capacity for repeated regeneration. Made by a controlled calcination of *beta*-trihydrate, its principal constituents are *beta*-alumina and *alpha*-monohydrate. The final product does not contain the usual *chi* and *gamma* aluminas. Results are minimum pressure drop, excellent thermal stability and large surface area.

For more information, turn to Data Service card, circle No. 51

industrial news

A lignin liquor processing plant put into operation at Appleton, Wisconsin, by Barcon, Inc. Start-up of the $300,000 unit is part of Consolidated Water Power & Paper's program of developing economic uses for the non-fibrous content of all wood species processed in their papermaking operations.

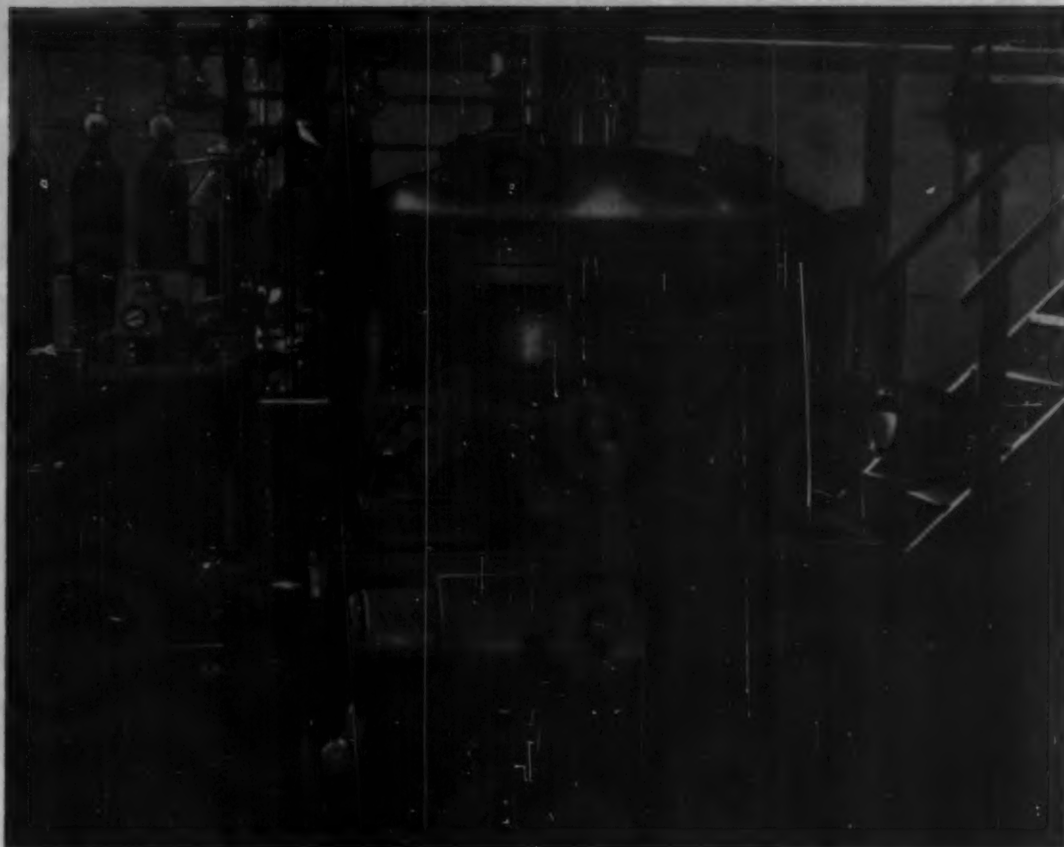
A thermal reformer placed on stream at the Kent refinery of BP Trading Co., in Great Britain. The 12,000 BPSD thermal reformer is designed for single pass thermal reforming of either light or heavy naphtha from Middle East crudes. The unit operates continuously for 2000 hours by using two 6000 bbl./stream day furnaces, either one of which can be taken out of service and brought back without interrupting the output.

A plant to process uranium dioxide for nuclear fuel use is scheduled for completion by Spencer Chemical. The 50 ton a year facility at the Jayhawk Works, near Pittsburg, Kansas, is the result of nearly two years of research on a continuous process for the manufacture of uranium dioxide. Company officials feels that the one arrived at produces a more uniform uranium dioxide than other processes now in general use.

Joint plans dropped for the construction of caprolactam plant at Ashland, Kentucky, by Spencer Chemical and Industrial Rayon. The venture had been under consideration since last July. Spencer will maintain the site, but has no immediate plans for its use.

A plant for calcining petroleum coke will be built by Kaiser Aluminum on a 20 acre site near Purvis, Mississippi. The facility will have an approximate capacity of 70,000 tons a year, and is scheduled for completion about September 1.

A grant to provide research experience for qualified science and mathematics teachers has been awarded Newark College of Engineering. The $15 thousand from the National Science Foundation will be used to conduct five projects at the NCE Laboratories for nine area high school teachers. Included in the projects are: Reductive Dehalogenation of Organic Halides, and Chemical Nature of Inorganic Ions in Solution. Candidates for the program, which runs from July 6 to August 31, are submitted to the college by principals and science department heads.



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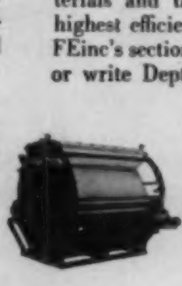

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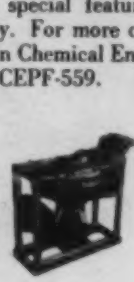

HORIZONTAL

SCRAPER

SPECIALISTS IN LIQUID-SOLIDS SEPARATION

For more information, turn to Data Service card, circle No. 97

A.I.Ch.E. JOURNAL

HEMICAL ENGINEERING RESEARCH AND DEVELOPMENT / MARCH 1959

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TURN

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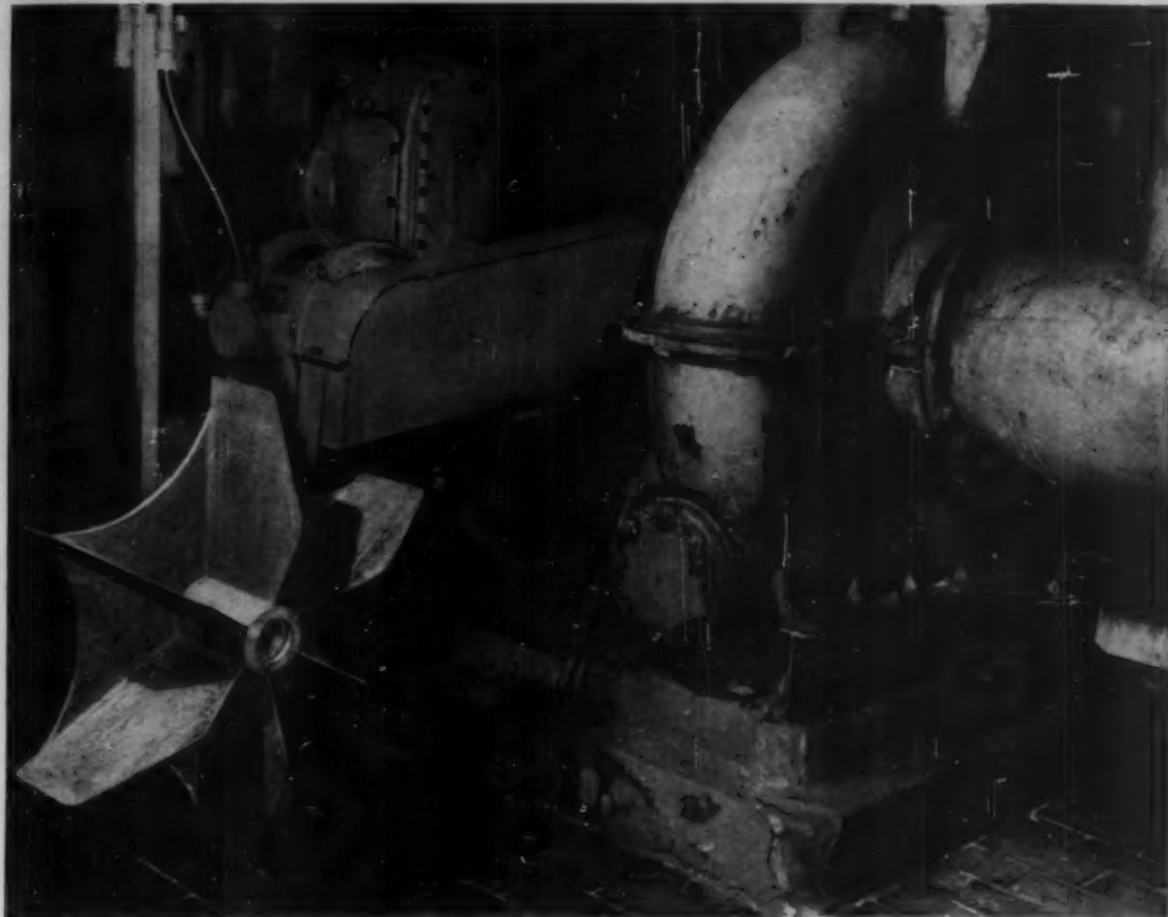
TURN



The impeller you see has been a spare for 10 years! Both it and the working impeller inside the housing at right are Illium "G", a 56% nickel alloy particularly resistant to the SO_2 gases handled by the blower. The blower is installed at the Crown-Zellerbach Corporation plant in Camas, Washington.

Spare nickel alloy impeller for SO_2 sits unused for 10 years!

...working impeller's still good for years to come

SO_2 gases are mighty hard on most impeller metals. *Yet, the spare impeller you see has not been needed since the blower went in over 10 years ago!* Blower exhausts 17% SO_2 gases at 90°F from pulp mill sulfur burners.

Both impellers are Illium "G"*, a high-nickel alloy cast by Stainless Foundry and Engineering, Inc., Milwaukee, Wisconsin. This high-nickel alloy provides superior resistance to the corrosive attack of many strong acids (particularly sulfur compounds), caustics, oxidizing and reducing agents, and sea water. It's readily welded and machined, too.

You'll do well to check the advantages of high-nickel alloys when designing for severe environments. Whether you're handling halogens, acidic or caustic corrosives, temperamental foodstuffs . . . whether temperatures are high or low, you'll find a nickel alloy to give you long, economical service.

*Registered trademark, Stainless Foundry & Engineering, Inc.

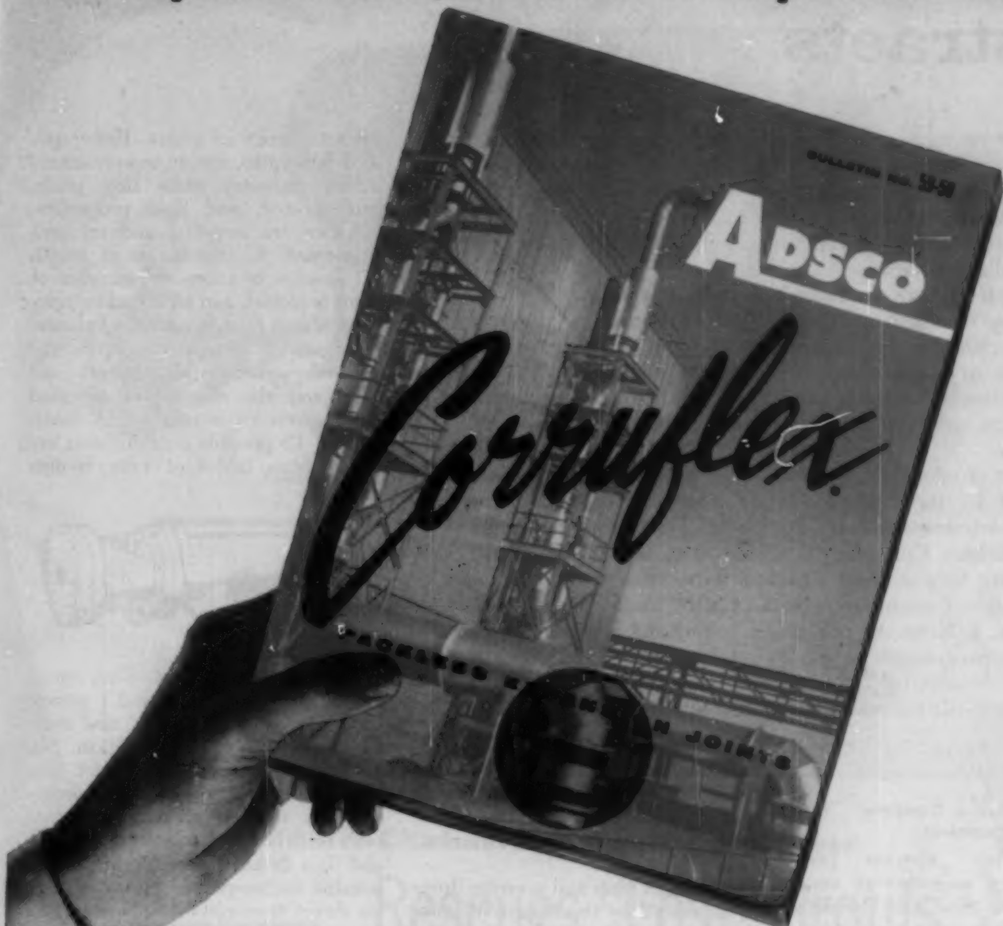
THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

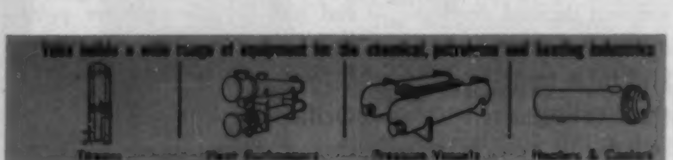
For more information, turn to Data Service card, circle No. 3

A New and Invaluable Reference Work for Design and Specification of Packless Expansion Joints



Every engineer working with piping that requires precise control of movement of any type, will find this new 76 page booklet one of his most valuable working references. ADSCO Corruflex Packless Expansion Joints in a wide range of metals and alloys, for high and low pressures and temperatures, are fully described and illustrated, with complete engineering and installation data and comprehensive tables of forces, movements and dimensions. You can rely on ADSCO . . . world's largest manufacturer of both packless and slip-type expansion joints.

A complimentary copy will be sent promptly in answer to inquiries. *Complete and attach coupon to your company letterhead, and mail today.*



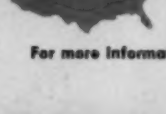
YUBA

ADSCO DIVISION

20 Milburn St., Buffalo 12, N.Y.

YUBA CONSOLIDATED INDUSTRIES, INC.

Plants and Sales Offices



Adsco Division, Yuba Consolidated Industries, Inc.
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CEP

For more information, turn to Data Service card, circle No. 24

CEP

COMPUTER PROGRAM abstracts

On this and the next page are four computer program abstracts—the first in a new and continuing CEP feature. Gathered and selected by the Machine Computation Committee of A.I.Ch.E., these abstracts, and the many to follow in the coming months, are the result of actual industrial programs, some of which have cost thousands of dollars to develop.

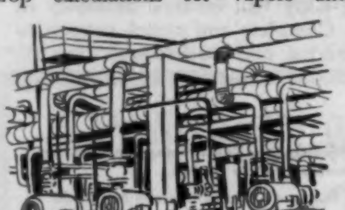
Virtually no interchange has existed for computer programs which have direct use to chemical engineers. For this reason, the Machine Computation Committee has undertaken this task. It is expected that publication of these computer abstracts, together with the planned publication of complete program manuals for large, general purpose programs, will help avoid duplication of effort and unnecessary expenditure.

In the interest of efficient operation of the program, three "rules" are emphasized by the Committee: 1) Abstracts submitted for publication must follow the form used here; 2) Abstracts must be sent to the Machine Computation Committee, not CEP; 3) *All* questions relating to published abstracts must be sent to the Machine Computation Committee, c/o A.I.Ch.E., 25 W. 45th Street, New York 36, N. Y. *Note:* All companies submitting abstracts agree to compile full program manuals for publication by A.I.Ch.E. if the Committee decides to publish them. However, A.I.Ch.E. does not intend to publish manuals of all abstracted programs.

Line sizing

Arthur G. McKee & Company
Oil Process Department

Description: This program performs calculations necessary to convert the units of flow and density; size liquid, vapor or water lines, based on a specified maximum pressure drop; and determine the pressure drop for a given diameter and length of pipe. The line sizing and pressure drop calculations for vapors and



liquids other than water are based on the Fanning equation. The original Colebrook formula has been used to obtain the friction factor for use in the Fanning equation.

. The roughness factor for commercial steel has been included in the program, and provisions have been made so that this value may be furnished as input data in each problem if the pipe material is other than commercial steel.

Water lines sizes and pressure drops are calculated by the Hazen-Williams Formula using C=100.

Computer: IBM 650 with alphabetic attachments.

Program language: Bell L_1.

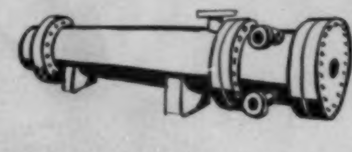
Running time: About 1 minute per problem.

Availability: A program manual has been written according to A.I.Ch.E. standards and is available for publication if sufficient demand develops.

Shell and tube heat exchanger rating

E. I. du Pont de Nemours & Company, Inc.
Engineering Department
Engineering Analysis by R. E. Githens
Programmed by E. T. Boone, D. M Mraz

Description: The program selects heat exchanger design for liquid-liquid, liquid-gas, or gas-gas service without change of phase. From specified flow rates, stream temperatures, desired geometry (tube size, pitch, pattern, etc.), and fluid properties, velocities are assumed and an area determined. A combination of length and number of tubes and number of passes is picked, and an actual velocity is calculated from a material balance. Based on a comparison with the assumed velocity, adjustments are made and the calculation repeated until agreement is reached. A maximum of 15 possible combinations are picked from tables of tube layouts



for standard shell sizes. They cover the range of 8, 6, 4, 2, and 1 passes; 16, 12, and 8 foot lengths, and overall diameters from 4 in. to 60 in. The program produces: 1) all input data for checking purposes; 2) a summary of areas, number of passes, etc., of each of the exchangers calculated; and 3) a detailed description of each suitable exchanger in a form suitable for direct transmittal to a vendor.

Computer: Univac I, 6 servos.

Program Language: 1 word floating decimal; "I" instruction not required.

Running time: 5 to 15 minutes per case, depending on the number of combinations desired.

Availability: A program manual is being written according to A.I.Ch.E. standards for internal company use and will be submitted for publication when completed.

Orifice Design

E. I. du Pont de Nemours & Company, Inc.
Engineering Department
Engineering Analysis by C. R. Otto
Programmed by T. J. Goddess, D. M. Mraz

Description: The program sizes orifices for metering or flow limiting of

continued on page 96

Computer programs

from page 94

liquids, gases, or steam. A "Beta" ratio (orifice diameter to pipe diameter) is assumed. The Reynolds number, expansion factor, orifice coefficient, etc., are calculated and compared with the assumed "Beta" ratio. This procedure is automatically repeated by trial and error until the correct "Beta" is found. The orifice bore, size and location of vent hole, position of taps, etc., are then computed. Fluid characteristics, flow conditions, and computing constants must be specified. Three separate edited outputs provide: 1) a recapitulation of input data for checking; 2) a report of problem data and calculated results, and 3) dimensions and other data required by a shop for fabrication of the orifice plate.

Computer: Univac I, 7 servos.

Program Language: GP, Fixed decimal.

Running time: 30 seconds per case.

Availability: Program manual has not been written. A manual will be prepared for A.I.Ch.E. publication if a sufficient demand develops.

Flange design

Arthur G. McKee & Company
Oil Engineering Department

Description: The program is based on the method found in the Taylor Forge publication entitled "Modern Flange Design". Automatic design and proportioning of the flange is not accomplished. The program will

check a given flange configuration and produce as output the stress at various points of the flange acting under specified conditions of loading.

Computer: Basic 650, 2000 word storage.

Language: Bell L_1 interpretive routine.

Running time:

Availability: A program manual has been written according to A.I.Ch.E. standards and is available for publication if sufficient demand develops.

A 15 million pound per year maleic anhydride plant, said to be the largest ever erected outside the U.S. will be built by Scientific Design for Monsanto Chemicals Ltd., at Newport, Monmouthshire, England. The unit is slated for startup late in 1960.

DURCO

TYPE K "Y" VALVES

***At* HEYDEN NEWPORT CHEMICAL CORPORATION,** *Bay Minette, Ala., these Durco Type K "Y" valves have been handling* **SULFURIC ACID AND BLEACH SOLUTION** *for almost three years with virtually no maintenance.*

Durco Type K "Y" valves provide positive closure without galling; maximum flow with minimum pressure drop; positive sealing at the stem with Teflon V-ring packing; renewable seat and disc ring of Teflon, Durimet 20, Duriron, or other alloys; and all stainless trim. The gland design utilizes rolling point contact of the gland follower, insuring proper pressure distribution and preventing stem scoring. Unique disc assembly permits renewal of disc ring, prevents failure in service, and extends valve life.

Durco Type K "Y" valves are available in Durimet 20, Durco 18-8-S-Mo, Monel, Nickel, Chlorimet 2, and Chlorimet 3. Complete details of construction are contained in Bulletin V/7a.

DURCO
CORROSION RESISTING ALLOYS & EQUIPMENT

THE DURIRON COMPANY, INC. / Dayton, Ohio

BRANCH OFFICES: Baltimore, Boston, Buffalo, Chicago, Cleveland, Dayton, Detroit, Houston, Knoxville, Los Angeles, New York, Pensacola, Philadelphia, Pittsburgh, and St. Louis

industrial news

A 25 percent increase in caustic soda and chlorine production capacity takes place at Stauffer Chemical's Niagara Falls plant. Stauffer is also converting the entire plant from 25 cycle to 60 cycle power. Changes, it is anticipated, will be finished by the end of this year.

A manufacturing plant for production of instruments and scientific apparatus to be built in Beda, Holland, by Cenco Instruments Corp. The 27,000 square foot unit, which will be operated by Cenco Instruments, Int'l. Zurich, Switzerland, also has provisions for large scale expansion. To fill immediate demands, the firm begins assembling and marketing vacuum pumps from rented headquarters until construction is completed in August.

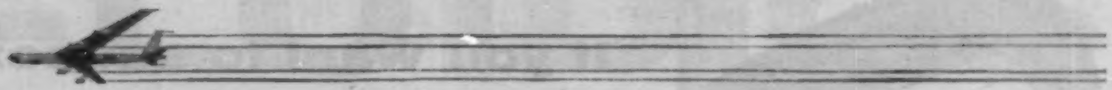
Formation of the Western Chemical Division of Hooker Chemical marked the final step in divisionalizing the firm's twelve plants. The Division consists of plants in Tacoma, Spokane, and North Vancouver, B. C., a storage terminal at Wilmington, California, and three sales offices. In other changes last month, the Eastern Chemicals Division was formed, with headquarters at Niagara Falls, N. Y., and the Phosphorus Division was made autonomous.

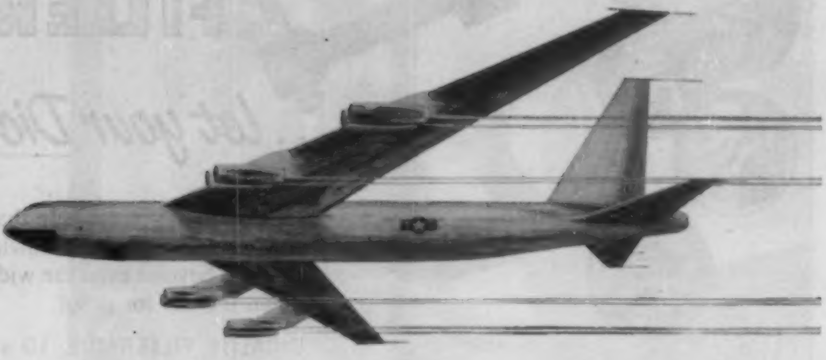
Natural gas will go to work for Cyanamid of Canada, Ltd., at its Welland, Ontario, plant, with the completion next year of a $5 million conversion program. Natural gas will replace imported coal in the manufacture of ammonia and ammonium nitrate, and the increased volume of production, it is predicted by Cyanamid, will supply most of the forseeable needs of Ontario and Quebec for nitrogenous fertilizers.

Irradiation space in the Westinghouse testing reactor has been offered to colleges and universities. A total of 3000 cubic inches in the reactor has been allocated, and is available to any research or study program financed by a college or university. This is said to be the first such offer by private industry to nuclear educators.

Price reductions on three amine-borane compounds effected by Callery Chemical. New prices per hundred pound lot, are: Pyradine-Borane $14.-00, Dimethylamine-Borane $20.00, and Trimethylamine-Borane, $22.00.

Thompson-Ramo-Wooldridge Products Co. has been named a division of Thompson Ramo Wooldridge, Inc.





she floats so jets can fly!

GATCO-200 . . . a new 230'x 43'x 15' oil barge built by INGALLS at its Decatur, Alabama Yard for Gulf Atlantic Towing Corporation of Jacksonville, will carry jet fuel for the armed forces. It is scheduled for coastwise service . . . has INGALLS exclusive patented bow, which reduces towing resistance, plus skegs to improve towing characteristics in coastal waters. It has a capacity of 20,000 barrels . . . is equipped with anchor and anchor-handling equipment and two Diesel-engine-driven pumps for unloading cargo. The GATCO-200 is further proof of INGALLS' ability to build the right barge for the right job at the right price. *On your next barge job, large or small, check with* INGALLS!

THE INGALLS SHIPBUILDING CORPORATION

Executive Offices: Birmingham, Alabama / Shipyards: Decatur, Alabama • Pascagoula, Mississippi (Two yards on the Gulf)

For more information, turn to Data Service card, circle No. 16

For more information, turn to Data Service card, circle No. 14

The following 4 Pages that appear to be missing are reader service cards and have been removed.

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Equipment *from page 104*

Mixers, top-entering (p. OBC). Propeller types, ¼ to 3 hp. Bulletin 103 from Mixing Equipment. **Circle 5-2.**

Mixers, top or bottom-entering (p. OBC). Turbine, paddle, and propeller types, 1 to 500 hp. Bulletin 102 from Mixing Equipment. **Circle 5-1.**

Nozzles, spray (p. 160). Catalog 24 and Data Sheets from Spraying Systems. **Circle 23.**

Packers, mechanical (p. 5). For boxes, cans, cartons, kegs, drums, barrels, up to 750 lbs. Bulletin 401 from B.F. Gump. **Circle 33**

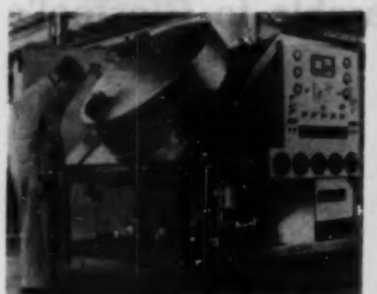
Packings, tower (p. 109). Comprehensive Booklet from Harshaw Chemical discusses application of "Tellerettes" to tower packing. **Circle 69.**

Piping, corrosion-resistance (p. 6-7). Details from Fibercast on high-strength, high-temperature, non-metallic pipe. **Circle 87.**

Piping, Teflon-lined (p. 107). Info from Resistoflex on Fluoroflex-T pipe and fittings. **Circle 41.**

Potentiometers (p. 21). Daystrom-Weston offers data on new constant-current source used in all its recording and controlling potentiometers. **Circle 26.**

DEVELOPMENT OF THE MONTH



BIG HIGH VACUUM STILLS (Circle 605 on Data Post Card)

High vacuum stills for volume production on a continuous basis are being offered by Consolidated Electrodynamics, Rochester Division. Principal applications are in separation of organic and silicone compounds in the molecular weight range from 250 to 4,000. Typical materials in the range include fatty acids, waxes, vegetable oils, epoxy resins, petroleum greases, tall oil, many pharmaceuticals.

Hourly throughput capacities are from 400 to 4,000 lbs, at costs estimated at from 0.06 to 0.1 cents per pound. Major factor in low processing cost is said to be a sharp reduction in heat in-put costs since, in the absence of atmosphere, boiling points can be lowered by 100 to 400°F. Second factor is increased yield, since heat-sensitive materials can be processed at lower temperatures.

For a copy of Bulletin 3-1, with complete specifications and application data, Circle 605 on Data Post Card.

Presses (p. 163). Floating-cone principle gives continuous automatic control of liquid or solids recovery. **Circle 37.**

Pumps (p. 111). Peerless Pump Div., Food Machinery and Chemical, offers 8-page Booklet on effects of radial loads in pump design. **Circle 46.**

Pumps, canned (p. 115). Pumps and motor in one unit, no seals or stuffing boxes. Info from Chempump. **Circle 98.**

Pumps, centrifugal (p. 13). New, multi-process pumps handle wide range of applications by interchangeability of parts. Data from Ingersoll-Rand. **Circle 73.**

Pumps, controlled-volume (p. 36). Leakproof chemical pumps with no stuffing boxes or other seals. Bulletin 440 from Lapp Insulator. **Circle 66.**

Pumps, controlled-volume (p. IBC). For accurate metering of corrosive liquids against pressure. Bulletin 553-1 from Milton Roy. **Circle 48.**

Pumps, gear (p. 128). Bulletin G-2 gives details of complete line of rotary gear pumps. Sier-Bath Gear & Pump. **Circle 116.**

Pumps, gear (p. 140). Packing, bearings, gears of Teflon, housings of 316 stainless, Carpenter 20, Monel, Hastelloy C, nickel, zirconium. Data from Eco Engineering. **Circle 90.**

Pumps, impervious graphite (p. 88). Single-stage centrifugals, 6 standard models, capacities from 5 to 300 gal./min. at heads to 100 ft. Bulletin from Falls Industries. **Circle 88.**

Pumps, peristaltic action (p. 162). For corrosives, abrasives, sterile solutions, gases. Two models—54 and 185 gal./hr. Data from Randolph Co. **Circle 27.**

Pumps, plastic, sealless (p. 130). Specially adapted for handling corrosive and abrasive solutions. Data from Vanton Pump and Equipment Div., Cooper Alloy. **Circle 77.**

Pumps, process (p. 124). "Pump Selector" offered by Nagle Pumps. **Circle 78.**

Pumps, process (p. 143). Technical data from Aldrich Pump on all types. **Circle 70.**

Pumps, rotary gear (p. 160). Bulletin G-1 from Schutte and Koerting gives full details on standard models. **Circle 105.**

Pumps, self-priming, stainless (p. 150). With plastic spur gears, capacity 3 to 50 gal./min. Catalog 58 has construction details, capacity charts. Ertel Engineering. **Circle 11.**

Refrigeration Units, jet-vacuum (p. 135). Details on the "Chill-Vactor" from Croll-Reynolds. **Circle 82.**

Rolls, crushing (p. 161). Bulletin 065 from Sturtevant Mill. **Circle 31-3.**

Rotameters, armored (p. 118). Specially designed for hazardous fluids. Bulletin 19A from Schutte and Koerting. **Circle 91.**

Separators, entrainment (p. 4). Bulletin 20 from Otto H. York describes applications of Yorkmesh Demisters. **Circle 117.**

Separators, line (p. 27). For efficient extraction of liquid mist from gas or steam. Details from Peerless Mfg. **Circle 36.**

Tanks (p. 144). Custom built from your specifications in all metals and alloys. Littleford Bros. **Circle 93.**

Tanks, wood, with polymer linings. (p. 140). Data from Wendnagel. **Circle 25.**

Thermocouple Wire (p. 154). Bulletin 1200-4 from Claud S. Gordon gives technical details, ordering info, prices on wire and accessories. **Circle 54.**

Trailer Trucks, plastic (p. 31). Available for immediate delivery or may be leased. Info from Haveg Industries. **Circle 65.**

Valves, high-alloy (p. 97). Bulletin V/7a from Duriron gives details of Type K "Y" valves, available in Durimet 20, Durco-18-8-S-Mo, Monel, nickel, Chlorimet 2, Chlorimet 3. **Circle 1.**

Valves, high-vacuum (p. 113). In sizes from ½ to 20 in., manual or remote-operated. Data from DeZurik. **Circle 9.**

Valves, miniature (p. 156). Catalog D-1, other technical data from George W. Dahl on pneumatic and hydraulic valves. **Circle 8.**

Valves, plug (p. 142). Bulletin J-57 from Hetherington & Berner describes 2 and 3-way spring-loaded, single spring-loaded, air-cylinder-operated, spring-loaded types. **Circle 52.**

Valves, plug, lubricated (p. 24). Available in sizes ½ to 16 in. Technical data from Wm. Powell Co. **Circle 19.**

Vessels, process (p. 150). In steel plate and alloys up to 1 in. Brochure T58 from Puget Sound Fabricators. **Circle 62.**

Viscometers (p. 157). The "Viscometran," made by Brookfield Engineering Laboratories, can measure, record, and control viscosity continuously. **Circle 55.**

Teflon-lined pipe helps plant save $60,000 per month... *enables corrosive process to stay on stream*

Problem: Excessive maintenance costs and product losses ran as high as $60,000 per month during first six months' operation of process at a major chemical plant.

The process for the manufacture of a chemical intermediate involves handling hydrochloric acid and organic liquids at temperatures exceeding 275°F. In the past, the highly corrosive properties of this combination had restricted material of construction to non-metallics.

Laboratory work established that many potential advantages could be obtained by increasing operating pressure from a normal level up to several atmospheres. However, a new material of construction would be required for the high pressure service.

An exhaustive search for satisfactory piping materials included a number of alloys, plastics, and other types of materials. The most promising of these were installed. In spite of this program, such frequent failures occurred that on-stream time averaged only 75% during the first six months' period of operation.

Solution: It was found that two experimental lengths of steel pipe lined with Teflon TFE-fluorocarbon resin had been placed on test previously. Both had provided excellent service for 24 months at 230°F and 10 psig. Both were then reinstalled in the new pressure system and were in operation for several more months without failure.

Based upon this and other encouraging results, conversion to steel pipe lined with TFE resin began as soon as it became commercially available. Plant now has more than 1500 feet of the lined pipe in service. Most of it is of 2" size although some up to 6" in diameter is in use. More than 400 Teflon TFE-fluorocarbon lined fittings are in use at the plant.

Results: No failures of the lined pipe have occurred. Some of it has already been in service more than 15 months. Outstanding performance of the lined pipe under the severe conditions has been a major factor in saving the $60,000 per month that was being lost through excessive maintenance and loss of product. Use of the lined pipe promises to make the process as reliable as those with no special materials of construction problems.

NOW OVER 2 YEARS

In the petroleum industry, pipe lined with Teflon has been found to be quite useful for handling hydrofluoric acid at elevated temperatures and pressures. Lined pipe has also proved valuable in chlorination, sulfonation, and nitration processes. Method used by manufacturer for lining pipe compensates for thermal expansion of liner to the extent that fatigue problems and reduction in flow diameter are eliminated.

(Fluoroflex-T pipe and fittings lined with TFE-Fluorocarbon resin are manufactured by RESISTOFLEX CORPORATION, Woodland Rd., Roseland, N. J.)

Reprinted with permission of CHEMICAL PROCESSING

Complete systems for corrosive service

Resistoflex

ROSELAND, NEW JERSEY · WESTERN PLANT: BURBANK, CALIF. · SOUTHWESTERN PLANT: DALLAS, TEX.

For more information, turn to Data Service card, circle No. 41

CEP's DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD, PAGE 103

EQUIPMENT

301 Analyzer, borane. Airborne borane monitored continuously in concentrations down to ten parts per billion. Technical details from Mine Safety Appliances.

302 Analyzers, colorimetric. Bulletin 1156-1 from Milton Roy gives details on analyzers for dissolved silica, dissolved oxygen, and total water hardness.

303 Chromatograph, gas. Data Sheet from Podbielniak describes features of the new "Chromacon" Series 9580.

304 Computer Linkage Systems. Electronics Associates offers new family of high-reliabilty analog-digital computer linkage systems. **Technical data.**

305 Controls, pressure. Bulletin from Mercoid Corp. describes newly-designed pressure control Type AP-153 for applications involving air or gases.

305 Desludgers, automatic. Brochure from Centrico exp'ains how continuous centrifuges purify fuel and lubricating oils, chemical products. Capacity chart.

continued on page 110

DEVELOPMENT OF THE MONTH

TRANSISTORIZED ANALOG COMPUTER
(Circle 609 on Data Post Card)

A low-cost analog computer, said to be capable of performing 95% of the routine mathematical operations encountered by an engineer in design calculations has been introduced by Electronics Associates. The new model TR-10 is 15 in. wide, 17 in. deep, and 24 in. high. It weighs only 80 lbs. without accessories. Price of the basic computer unit starts from under $4,000; accessories such as read-out equipment are extra.

The machine is expected to be particularly adapted to solution of problems in chemical engineering such as studies in kinetics, steady-state material and heat balances, blending and mixing problems, drying calculations, etc.

For more details of this low-cost computer, Circle 609 on Data Post Card.

MATERIALS

358 Algaecide. Technical data from Calgon Co. (Div. of Hagan Chemicals & Controls) on new algaecide for controlling microbiological growths in cooling towers.

359 Alloys, molybdenum-containing. Data from Cooper-Alloy on new group of molybdenum-containing alloys of the 18-8 group.

350 Borohydrides. Synopsis of 18 publications on borohydride reductions in cellulose chemistry, and 15 in sugar chemistry contained in annotated bibliography from Metal Hydrides Inc.

361 n-Butyllithium. Data Sheets from Lithium Corp. of America give physical and chemical properties, analysis, uses, availability, Bibliography.

362 Cacodylic Acid. Reference Booklet from Ansul Chemical gives chemical and physical properties, toxicological properties, applications.

363 Coatings, heat-resistant. Brochure from Midland Industrial Finishes gives properties and applications of "Sicon" silicone-base finishes for high temperature coating.

364 Coatings, high-temperature. Brochure from Continental Coatings describes the flame ceramic process for protecting metals against temperatures to 5,500°F.

365 Coatings, mastic. Comprehensive Loose-Leaf Notebook from Benjamin Foster Co. covers coatings, sealers, adhesives for refineries, chemical, petrochemical plants.

366 Esters. New 48-page Booklet from Union Carbide Chemicals gives basic reference data including 27 graphs and charts on evaporation rates, viscosities of resin solutions, dilution ratios, specific gravities, constant boiling mixtures.

367 Ethylene Amines. New, 65-page Booklet from Dow Chemical gives properties, reactions, uses, handling and storage data, bibliography on patent and use sources.

368 Fiber, polyvinyl alcohol. New Bulletin from Air Reduction describes "Vinylon," Japanese polyvinyl alcohol fiber now being marketed in U.S.

369 Hydrochloric Acid. Comprehensive data on production, uses, properties, handling, in 40-page Brochure from Stauffer Chemical.

370 Insulation. Brochure from Dow Chemical on "Styrofoam" pipe and vessel applications for low-temperature insulation. Application data, charts on thickness and heat gain.

371 Linings, for containers. Data Sheets in Loose-Leaf Folder from Lining' Engineering Div., Lithcote Corp.

continued on page 110

SERVICES

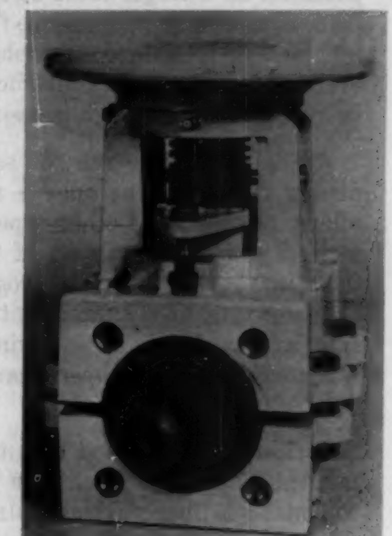
382 Design by Computer. New, 12-page Brochure from M.W. Kellogg titled "The Computer: New Era in Engineering," describes use of the computer as a process and design engineering tool.

383 Engineering Constants Reference Book. Brochure from Falcon Mfg. Div., First Machinery Corp. gives engineering constants, short-cut tables, formulas, technical data for practical plant operation.

384 Fabrication, process equipment. Bulletin GEN-58 from Industrial Filter & Pump describes pressure filters, ion exchangers, demineralizers, pumps, heat exchangers, waste treatment systems.

385 Fabrication, process equipment. Bulletin from Puget Sound Fabricators describes facilities for fabrication of process equipment in all alloys and clad metals.

DEVELOPMENT OF THE MONTH



IMPERVIOUS GRAPHITE GLOBE VALVE
(Circle 606 on Data Post Card)

A new "Karbate" impervious graphite globe valve with a non-rotating spindle is available from National Carbon. The sliding spindle design makes it easier to seal off the valve packing, and makes the valve adaptable to motorized, automatic operation. A wide range of packing materials has been found suitable—asbestos, braided Teflon, asbestos impregnated with Teflon, and a variety of elastomers.

The valve is now available in the 2 in. size, will be made soon in 1, 1½, 3, and 4 in. sizes. Service pressure is 100 lb./sq. in. The valve can be operated in the horizontal, vertical, or 45-degree position. For more technical details, Circle 606 on Data Post Card.

CEP's DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD, PAGE 103

Equipment *from page 108*

307 Dryer, rotary vacuum. Bulletin from Alloy Fabricators Div., Continental Copper and Steel Industries, gives details of the "Rovactor," for multi-purpose processing.

308 Dryers, spray. Bulletin from Proctor & Schwartz gives details of production, pilot-plant, and semi-works models.

309 Dust Collectors. New, 20-page Product Bulletin 272B from American Air Filter gives applications, principle, design, construction, operation, installation data.

310 Dust & Fume Control Systems. Comprehensive 52-page Catalog from Kirk & Blum Mfg. covers wet, dry, electrical, and centrifugal collection.

311 Fans, high-temperature. New, 82-page Catalog from Garden City Fan Co. gives technical data on complete line of "Thermal-Aire" fans for temperatures to 1,850°F.

312 Filters, portable, magnetic. Rotating magnetic field drives pump impeller, eliminating seals or stuffing glands. Details from Sel-Rex.

DEVELOPMENT OF THE MONTH

HEAT EXCHANGER BULLETIN (Circle 601 on Data Post Card)

A complete Specification Manual on double-pipe or hairpin heat exchangers is offered by Brown Fintube. The manual is broken down into 7 major sections. In addition to general specifications which cover codes, scope, guarantees, and drawings, there are sections on design, materials, welding procedure, testing, inspection, and preparation for shipment. Sub-assembly drawings are incorporated into the back of the Manual. The Brown Fintube system of using a single modular unit for all heat exchanger duties, permits a maximum of flexibility in design and specification. For copy of Specifications Manual M-100, Circle 601 on Data Post Card.

314 Flow Integrator. Vertical motion of rotameter translated into rotary motion; integration accomplished photoelectrically. Details in Bulletin 170 from Brooks Rotameter.

315 Flow Rate Calibrator, portable. Design Specification Sheet SS-903 describes unit for checking rotameters, other flow devices with inert gases in range of 1 to 5,000 cc/min. Brooks.

316 Flow Rate Indicator, transistorized. A new transistorized, servo-driven flow rate indicator for F&P magnetic flowmeters offered by Fischer & Porter. Said to cost about one-quarter as much as formerly existing indicators.

317 Heat Exchangers, finned-tube. Dimensions, mechanical specifications, physical data on steel and non-ferrous heat exchangers. Bulletin 3-R from Alco Products.

318 Heat Exchangers, impervious graphite. Bulletin 537 from Falls Industries covers cubical and cross-bore impervious graphite heat exchangers.

319 Heat Transfer Equipment. Bulletin 259 from Dean Products gives specifications and price info on Thermo-Panel Coils, designed to replace pipe coils in tanks, reactors, mixers.

320 Heat Transfer Systems, liquid-phase. Data from Trent, Inc., on the Merrill Process System, designed by Parks-Cramer, employing Trent finned-tube design with radial fins parallel to heater axis.

321 Homogenizer, miniature. Operates from 100 to 3,000 lb./sq. in. Results transferable directly to production-scale homogenizers. Details from C. W. Logeman Co.

322 Instruments, laboratory. Forty-seven-page Booklet from E. H. Sargent gives up-to-date specifications and prices on laboratory apparatus and instruments.

323 Liquid Handling Equipment. Bulletin 58 from Ertel Engineering describes many types of filter sheets and filtering equipment. Application tables, flow rate and filtration area charts.

324 Meter, Btu. Data Sheets and Price Lists from American Meter.

325 Mixers, mass and paste. Technical data from Paul O. Abbe on new line of mass and paste mixers in sizes from 3 to 300 gallons. Various materials of construction.

326 Nozzles, spray. Capacities, sizes, dimensions, materials of construction in Bulletin 6A-622-2 from Schutte and Koerting.

continued on page 112

Copy of paper on "Organization and Preparation for Start-Up of a Unifiner-Platformer" by Barnett (delivered at A.I.Ch.E. National Meeting, Atlantic City, March, 1959). Forty-two copies available. Circle 600 on Data Post Card.

Materials *from page 108*

372 Organic Acids. Technical Bulletins give reactions, shipping and toxicological data on valeric, iso-pentanoic, and 2-methylpentanoic acids. Union Carbide Chemicals.

373 Pigments, aluminum silicate. Physical, chemical properties, analysis, percent residue, oil absorption, color, refractive index, specific gravity, bulking value, pH, free moisture content, in Technical Information Bulletin 1001 from Minerals & Chemicals Corp. of America.

374 Polystyrenes. Technical Bulletin C-9-231 from Koppers Co. gives charts on properties, application data.

375 Rare Earth Metals. Data Sheet and Price List on yttrium, lanthanum, cerium, praseodymium, neodymium, samarium, gadolinium, terbium, dysprosium, holmium, erbium, ytterbium. Nuclear Corp. of America, Research Chemical Div.

376 Resins, isophthalic. Samples and Data Sheets offered by Oronite Chemical on new isophthalic-based alkyd and polyester resins.

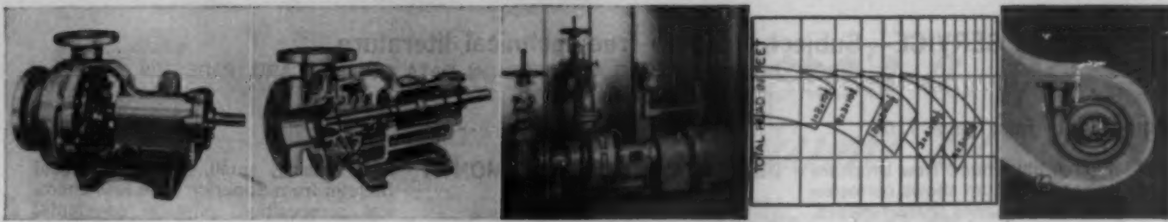
377 Silica Mortar. Data Sheets from Pennsalt Chemicals describe "Synar," improved silica mortar for construction of masonry linings in acid containers, such as storage tanks, concentrators, absorbers.

378 Silicon Carbide Foam. Technical Data Sheet from Carborundum Co. describes silicon carbide foam, new lightweight, corrosion-resistant material with high porosity and good thermal insulation properties up to 4,000°F.

379 Sodium Formate. New, 8-page Booklet from Heyden Newport Chemical gives specifications, properties, characteristics, applications.

380 Sodium Phosphates. Technical Bulletin and Use Reference Guide from Monsanto, Inorganic Chemicals Div., gives physical and chemical properties, applications of many sodium phosphate products.

381 Synthetic Rubber. Goodrich-Gulf Chemicals offers 16-page data and specification book on new "Ameripol Microblack" masterbatch synthetic rubbers. Complete specifications on 7 types of the material.



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For more information, turn to Data Service card, circle No. 46

Equipment *from page 110*

327 Piping, aluminum. New Brochure from Kaiser Aluminum shows corrosion resistance, performance characteristics, bursting pressures at elevated temperatures, mechanical properties.

328 Pressure Sensing Unit. For precise measurement of differential pressure, flow, liquid level. Bulletin 224-1-1 from Barton Instrument.

329 Process Control Systems. Bulletin from GPE Controls describes the Libratrol - 500, flexible computerized control system adaptable to both existing and in-design processing systems.

330 Pulverizers. Bulletin 242 from Gruendler Crusher & Pulverizer gives details of production and experimental models.

331 Pumps, centrifugal. Details from Frederick Iron and Steel on line of double-suction, single-stage centrifugal pumps. Bulletin 104-A.

332 Pumps, centrifugal, impervious graphite. Bulletin 854-1 from Falls Industries gives details of centrifugal graphite pumps with new seal design.

333 Pumps, centrifugal and rotary. New, 72-page Catalog from Detroit Harvester, Paris Products Div., describes open-impeller centrifugal pumps, in both sealed and sealless types, and positive displacement rotary pumps.

334 Pumps, feed, chemical, Capacities to 65 gal./24 hr., pressures to 125 lb./sq. in., temperatures to 100°F. Data from Fischer & Porter.

335 Pumps, metering. Bulletin MP-29 from Clark-Cooper gives details and specifications of new line of plunger-type and diaphragm-type metering pumps.

336 Pumps, metering. High-pressure, low capacity, variable volume, reciprocating plunger pumps—capacities from 1.5 to 108 gal./hr. Details from Walter H. Eagan Co.

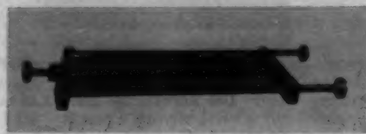
337 Pumps, metering, automatic. Packless, pneumatic-stroke-controlled "McCannameter" automatically proportions chemicals to any main line flow. Details from Hills-McCanna.

338 Pumps, slurry. Capacities and ranges of heavy-duty slurry pumps given in Bulletin 189 from Morris Machine Works.

339 Pumps, titanium, centrifugal. Pumps and valves of commercially pure titanium now available from Duriron. Technical data.

340 Radiation Equipment. Illustrated Booklet from Picker X-Ray Corp. considers advantages and disadvantages of X-radiation and gamma radiation for inspection purposes.

DEVELOPMENT OF THE MONTH



GRAPHITE GRID HEAT EXCHANGERS
(Circle 607 on Data Post Card)

Impervious graphite grid-type heat exchangers, made by Heil Process Equipment, are being used successfully by a large processor of rare metals to concentrate tantalum fluoride by evaporation. They can also be used to concentrate solutions of the salts of titanium, uranium, zirconium, beryllium, hafnium, plutonium, other rare metals. The "Nocordal" grid-type units are placed in the bottom of the crystallizer. Inlet and outlet connections extend through the walls of the crystallizer, and connect with the inlet stem and exhaust lines.

A revolving agitator blade, rotating horizontally directly above the grid, circulates the salt solution, increasing heat transfer, and speeding evaporation. The exchangers are made in a wide range of standard types and sizes, and can also be custom fabricated to meet unusual requirements. For complete details, Circle 607 on Data Post Card.

341 Recorders, strip-chart. New, 8-page Brochure from Varian Associates describes strip-chart recorders said to combine exceptional versatility with light weight and compactness.

342 Screens, vibrating. New, 48-page Book from Link-Belt describes 12 different types in 212 sizes. Complete tables of materials, selection data, construction features.

343 Spectrometer, mass. Bulletin 1800 from Consolidated Electrodynamics describes principles and operation, gives diagrammed explanation of working principles, applications, analysis procedures, description of components and features.

344 Spectrophotometers, infrared, accessories. Perkin-Elmer offers three new accessory data sheets, describing a variable thickness liquid absorption cell, a small volume gas cell, and an evacuable potassium bromide die.

345 Teflon Products. Catalog 80 from Crane Packing gives details of mechanical and hydraulic packings, sheet, rod, tubing, tape, flexible bellows and gaskets, molded and machined parts.

346 Tubes, bi-metal. Brochure (24 pages) from Bridgeport Brass describes solution of condenser and heat exchanger problems involving two different corrosive media.

347 Tubing, small, Monel. Technical Bulletin from Superior Tube lists chemical composition, physical constants, mechanical properties of Monel, "R" Monel, "403" Monel, and "K" Monel.

348 Valves, control. Bulletin 300 from W. H. Nicholson gives specification and design features of 3- and 4-way control valves.

349 Valves, corrosion-resistant. Bulletin 9 from Alloy Steel Products defines applications of cast Monel and nickel valves to corrosive environments. Chemical and mechanical properties, basic design features.

350 Valves, corrosion-resistant. Bulletin from Automatic Switch Co. has special selection chart for corrosion-resistant solenoid valves.

351 Valves, flow control. New Catalog Sheet from Syntron gives details of "iris-type" flow control valves for positive flow control of bulk materials and air.

352 Valves, pressure-reducing. Bulletin J-1160 from OPW-Jordan describes sliding-gate, pilot-operated, pressure-reducing valve for utmost sensitivity and extreme pressure reductions.

353 Valves, PVC. New Brochure from Lunkenheimer gives corrosion table, weights, dimensions.

354 Valves, relief. New, 84-page Catalog from Marine & Industrial Products gives engineering charts and data, valve discharge capacity tables for liquids, air and gas, and steam.

355 Valves, remote-control, automatic. Technical Data Book from G&H Products gives details on operation of automatic control systems.

356 Valves, solenoid. Catalog from Atkomatic Valve lists more than 200 solenoid valves in bronze and stainless. Specifications, performance date, applications.

357 Waste Recovery Systems. Two nomographs, one on value of recovered water, the other on amount of waste chemical which can be recovered, offered by Graver Water Conditioning.

A.I.Ch.E. Membership

Brochure—"Know Your Institute"—tells objective aim and benefits to chemical engineers who join this nation-wide organization, includes membership blank. Circle number 604 on Data Post Card.

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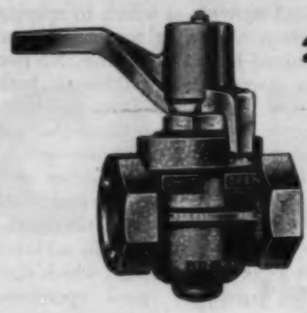

2. Extremely Low Leak Rate

3. Straight-Thru Flow for Low Impedance

4. Low Initial Cost

Used on high vacuum, air release or throttling service, DeZurik Valves combine the unique advantages of eccentric action and resilient plug facing to provide the special requirements of high vacuum service.

Their simple, positive action assures longer service life with less maintenance.

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DeZurik Valves for vacuum service are available in sizes from ½" to 20 and in manual or remote operated models. See the DeZurik representative near you, or write for details.

Each DeZurik high vacuum valve is tested before shipment. Tests are made with the most accurate equipment available, a Helium mass spectrometer type leak detector.

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For more information, turn to Data Service card, circle No. 9

Demisters for Sulfuric Acid Plant Stacks

Wire mesh filters prove efficient in control of sulfuric acid plant stack gas—case history data from Stauffer's Houston operation.

The sulfuric acid manufacturing facilities of the Consolidated Chemical Industries Div. of Stauffer Chemical at Houston, Texas, consist of four sulfur-burning contact plants and two alkylation acid regeneration plants. These plants exhaust a total of about 2,200 cu. ft. (STP)/sec. of gas to the atmosphere. This gas is about 92% nitrogen, 8% oxygen, and contains traces of SO_2. In the case of the acid regeneration plants, the stack gas also contains CO_2. Stack temperatures vary from 150 to 200°F, and gas velocities from 15 to 40 ft./sec.

These velocities are capable of entraining quite large particles of acid mist from the absorption towers. The installation of larger or more stacks would be a very expensive undertaking—one that could not be justified economically on the basis of decreased back pressure or resistance. When oleum is manufactured (100% H_2SO_4 plus excess SO_3 in solution), a very fine mist is generated which defies any ordinary entrainment separator (including the ones presently in use at Consolidated). However, all the large trouble-causing particles can be filtered out. The extremely small particles remaining (probably less than 2 micron), while highly visible, represent very few pounds of acid.

Figure 2. Two stage wire mesh filter performance, velocity 12 to 15 feet per second.

Pressure Drop In. H_2O	Inlet Mg. H_2SO_4/cu. ft.	Outlet Mg. H_2SO_4/cu. ft.	Efficiency %
1"	8.8	0.7	92.5%
¾"	4.1	0.74	82.0%
1¼"	13.8	0.92	93.4%
1¼"	66.9	0.77	98.9%
1¾"	32.5	0.98	97.0%
1¾"	13.0	0.76	94.1%

Acid mist sources

Culprit number one is probably unabsorbed SO_3. Usually, the correct acid strength at which to operate any given absorbing tower must be determined by trial and error. No two towers operate alike, although both may have been built from the same blueprints. Best absorption—that is, the least visible stack plume—is usually found when the absorber acid strength is somewhere between 98.3% and 99.2%; for any given tower, the range is only about 0.3%. In addition to factors of tower design, which cannot be cured by good operation, insufficient acid circulating over a tower may release unabsorbed SO_3; flooding and channeling may do the same thing. Free SO_3 turned loose in the atmosphere forms a sulfuric acid mist of extremely small particle size, which is to a high degree obscuring to light.

Moisture can be formed from the burning of dark sulfur which contains hydrocarbons and other organic impurities. Such hydrocarbons can contribute the nuclei necessary for sulfuric acid mist formation, and will do so when the temperature reaches the dew point of sulfuric acid. This can happen even though the gas as a whole never reaches the dew point temperature. Sudden chilling can occur, for example, on the skin surface of the steel ductwork carrying SO_3 into an absorbing tower; a shower of rain can have the same effect. Any moisture not removed by the drying tower is potentially mistforming. A tiny steam leak, introduced at the sulfur burner, can create a badly smoking stack, as can economizer or boiler leaks.

From observation at Houston, mist formed by mechanical entrainment is the most easily removed. A simple

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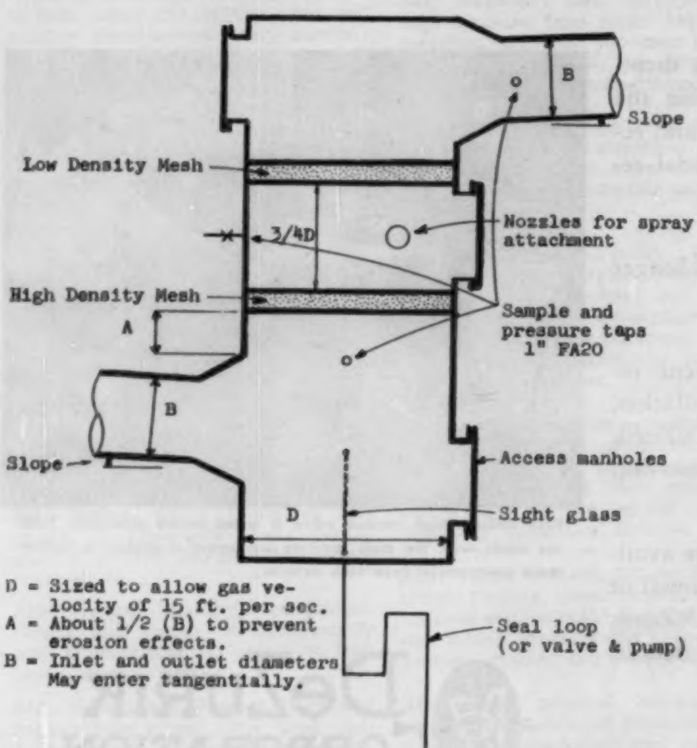

Figure 1: Typical stack gas filter.

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For more information, turn to Data Service card, circle No. 98

Demisters

from page 114

baffle box, or any device which changes the direction of the gas flow, is usually sufficient.

Many of the stack-spitting problems at Consolidated have been tracked down to the powdery-dry iron sulfate that accumulates in stack ducts. Only solution found so far is to wash down the stacks periodically.

Temperature of absorber acid, absorber acid acidity, temperature of SO_3 gases, rate of acid circulation, gas velocity, tower design, SO_2 gas strength at the converters, type of tower packing—all these factors, singly or in combination, appear to have a direct bearing on mist formation.

Remedies investigated

Cyclone-type demisters have been found to be of limited usefulness on stack exit gas. Large particles (20 microns) can be eliminated, but considerable power must be expended to remove the smaller sizes.

Packed beds of various sorts have been tried. Coke, quartz, rings, and saddles all have value in certain applications. A one-foot bed of 1 in. Berl saddles contained in a vessel so sized that gas flow is 10 to 12 ft./sec. will stop a lot of acid mist with a pressure drop of only about 1 in. H_2O. A typical test at Houston gave:

Loading into filter	25.8 mg. H_2SO_4/cu.ft. gas (STP)
Loading leaving filter	11.6 mg. H_2SO_4/cu.ft. gas (STP)
Efficiency	55%
Pressure drop	1¼ in. H_2O
Velocity	12 ft./sec.

Higher velocities will cause re-entrainment. Without excessive pressure drops and thicker beds, acid mist loadings have not been reduced to the 2 mg./cu. ft. desired.

Considerable experimental work on the use of glass fibers as a stack gas filtering medium has been done at the Houston plant. It has been found that these fibers tend to pack when wet and, although efficiency was high, it was difficult to force the gas through.

A vane-type filter, consisting of ten staggered rows of tear drop shaped parallel vanes gave comparatively good results, except that the material of construction (molded carbon) proved unsuitable at 190°F in the presence of 98% sulfuric acid. One of these filters, at a face velocity of 30 ft./sec. gave an efficiency of 50%.

Excellent efficiency was also obtained with patented German (Lurgi)

filters consisting of porous ceramic thimbles held in a horizontal tube sheet. This is an efficient filter but expensive to maintain. The ceramic tubes are subject to breakage; the area required is large, as is the pressure drop. However, on acid regeneration plants, this filter consistently reduced outlet gas loading to 1 mg. H_2SO_4/cu. ft. Pressure drop, however, was 7 to 11 in. H_2O.

Knitted wire mesh filters

Most practical method has been found to be the knitted wire mesh filter, used in two stages. Such filters, made commercially by several U.S. manufacturers, have been used extensively in the oil industry; Consolidated's Houston plant is believed to be the first application to sulfuric acid manufacture.

Practice at Houston has been to install the filters in two stages, generally separated by a distance equal to ⅝ of the vessel diameter (Figure 1). A light metal grid above and below the mesh is desirable. The filters are made in sections and come assembled with the supporting grids. In operation in the correct velocity range, a layer of the entrained liquid is held within the wires of the filter. This liquid scrubs the gas stream, increases its velocity, and hence increases impaction of fine particles. Too high a velocity will re-entrain the scrubbing liquid. For sulfuric acid stacks, experience at Houston has indicated an optimum velocity of 15 to 18 ft./sec. in the duct approaching the filter. It has been found that the velocity can drop as low as 10 or 11 ft./sec. Figure 2 shows typical results with the use of wire mesh filters. In general, it can be said that a 2-stage wire mesh filter will reduce the acid in stack gas to 1 or 2 mg./cu. ft. at a pressure drop of 1.5 to 2 in. H_2O.

Materials of construction critical

The first wire mesh filter installed at Consolidated was made of Carpenter 20: the lower stage showed considerable corrosion after 14 months and was replaced. However, it appears that most of the damage may have been done by weak sulfuric acid during certain experiments. Following this experience, a Hastelloy B wire mesh was installed in one of the regeneration plants. Unfortunately, this alloy, although immune to 98% sulfuric acid, will not tolerate traces of nitric acid. Sulfur-burning sulfuric acid plants have only traces of nitric, but regeneration plants have considerably more in the stack drip, probably from nitrogen compounds in the feed

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Demisters

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acid. In any event, three months' operation destroyed a Hastelloy B filter pad, the lower one of two, without harming the upper one which was of Carpenter 20.

In one sulfur-burning plant, a Hastelloy C wire mesh filter, on inspection after one year's service, appeared in perfect condition; operation is still perfect after nine month's additional service. A Hastelloy C filter will be installed in a regeneration plant; this is expected to be immune to the traces of nitric acid present. In general, the relatively inexpensive FA-20 alloy appears to be the cheapest and most practical alloy for this service; as pointed out above, the corrosion experienced in one case may well have been due to other factors.

Condensed from *"Demisters for Sulfuric Acid Plant Stacks,"* O. D. Massey, Stauffer Chemical Co., given at Air and Water Pollution Abatement Conference, MCA, Cincinnati, March, 1959.

Two RW-300 Digital Control Computers, said to be the first connected directly to nuclear reactor instruments, will be utilized by France's first commercial nuclear power plant. Construction on the plant, believed to be the largest in the world, is under way near Chinon, France. The facility will have a rated output of 300 megawatts of heat and 80 of electricity. Start-up of the first reactor is scheduled for the summer. Work is being done by Electricité de France, government owned power utility.

Phthalate ester plasticizer facilities just completed at Allied Chemical's Toledo, Ohio, plant, are expected to boost output. The new facilities will serve the midwest by direct bulk and drum shipments, as well as through six bulk stations in major cities.

The increased importance of chemical products and processes in the National Starch Company's business is reflected in a proposal to change the corporate name to National Starch Chemical Corp. A substantial part of present sales are in chemical products, and many of the adhesive, starch and other manufacturing operations involve chemical processes. National Starch produces vinyl acetate polymers and copolymers in emulsion form for the adhesive, packaging, paper, textile, paint, and other industries.

from page 8

1959 Engineering Societies Directory, (rev. 1959) $3.50, Engineers Joint Council, New York, N.Y.

The first revision since 1956 of this comprehensive directory which provides basic information concerning engineering groups, from international organization to local bodies.

Automatic Measurement of Quality in Process Plants, Academic Press (1958), New York, N.Y., 320 pp., $9.50. (Published for the Society of Instrument Technology.)

Papers covering two aspects of the field: those that survey the experience gained with the control instruments now in use, and those that explore the potential plant application of analytical methods used currently only in the laboratory. Specific topics include techniques for gas stream analysis, spectrometric methods, liquid stream analysis, new techniques for fluid stream analysis, and measurement of various physical properties.

Process Dynamics, Donald P. Campbell, John Wiley & Sons, New York, N.Y. (1958), 316 pp., $10.50.

An examination of the characteristics of processes under unsteady-state conditions, or in response to periodic disturbances. Those aspects treated include kinematics of materials handling; fluids in motion; forming, propulsion, and guidance; thermal process, mass transfer, and chemical process dynamics. A special feature is the coverage given to methods for controlling process operations involving moving filaments, sheets and webs.

Reports of the results of the government program for research on radiation sterilization of foods have just been released. Conducted for the Quartermaster Food and Container Institute for the Armed Forces, reports, in the form of booklets, consist of nine separate studies made at various research centers throughout the country. Available from the Office of Technical Services, U.S. Department of Commerce, Washington, D.C.

Corporate Diagrams & Administrative Personnel of the Chemical Industry, has just been issued in the 1959 edition. Copies, which include a supplement to be issued in September are available at $20, from Chemical Economic Services, Princeton, N.J.

Construction to start on Engineering Center

The date has been set, plans are in the last stages of completion, the permanent home of the Engineering Societies now enters the final phase of development.

With the setting of October 15 as the date for construction to begin on the United Engineering Center building on United Nations Plaza in New York city, the Center moves one large step closer to completion. Present tentative schedule, according to directors of the project, calls for the United Engineering Center to be completed by March 15, 1961. Occupancy is expected by July 1, 1961.

According to U.E.T., other dates have been set on construction plans for the building. Working drawings are due for completion August 30, 1959; while confirmation of guaranteed limit of cost should be received from Turner Construction Company on September 30.

The drive for funds for the $10 million structure continues with renewed vigor. Latest reports from A.I.Ch.E. show excellent prospects for the Institute to go over the top very quickly. Over $290,000 has been subscribed to date out of a total quota of $300,000.

A one-stage process for the production of lysine has enabled the Merck Co. to reduce prices on the chemical by 25 percent. The process, which replaces the extraction method at Merck, is considered an improvement over two-stage fermentation and synthetic methods. Licensed from Kyowa Industries, Ldt., Japan, the process has been brought on-stream at the company's Stonewall plant at Elkton, Va.

New chlorine caustic soda unit startup at Wyandotte Chemical's Geismar Works, near Baton Rouge, La. The $26-million plant is the second unit to go on stream at Wyandotte's southern chemical manufacturing complex since last June. When full production is reached late this year, capacity will be 300 tons a day of chlorine and 330 caustic soda.

Selection of Components for Gas Analyzer Sampling Systems

Important savings found possible by judicious use and adaptation of existing commercial equipment.

J. L. Cotter and L. E. Maley
Mine Safety Appliances Co.

Selection of the components of gas sampling systems can be as important to the performance of a gas analyzer as the analyzer itself. In some instances, the cost of developing a system may equal or exceed the cost of the analyzer. In other instances, unnecessarily expensive components may be used because the availability of suitable, less-expensive components is not known.

An attempt has been made here to evaluate significant characteristics of some of the commercially available filters, pressure regulators, valves, condensate traps, and sample conditioners with respect to advantages, limitations, and costs.

Filters

Many filters useful in this work were not designed primarily for instrument flow systems. Consequently, in some cases, excess volume, materials of construction, and other factors must often be taken into consideration in selection.

Sack-type filters are simple, inexpensive throw-away units, used extensively in the refrigeration industry, and in compressed air lines. Usually they consist of a fiberglass sack and fine screen enclosed in a sealed chamber through which the sample passes. Price range is from $10 to $15. Typical suppliers are: Superior Valve and Fittings Co; Mueller Brass; Imperial Brass.

Figure 1. Filter with cyclone separator trap and fibrous filter element. To 10 microns at 150 lb./sq. in.

Figure 2. Small pressure regulator for use with analyzers operating at atmospheric pressure.

Filters designed for use with pneumatic tools usually have replaceable cartridge elements made of either a fibrous material or porous bronze. A cyclone separator or trap may be incorporated in a metal or transparent plastic bowl. Performance of the unit (Figure 1) has been excellent in a number of instrument systems. Filter action is 10 microns, pressure rating 150 lbs./sq.in. as shown, or 500 lb./-sq.in. with metal case. Samples enter the head of the unit, and travel a centrifugal path into the bowl and back through the fibrous element to the opposite side of the head. Condensate is drained through a petcock in the bottom or by an automatic float-type ejector. Price range is $20 to $50; suppliers are MB Products, Arrow Tools, Master Pneumatic, and others.

Custom designed units of the two types described above are available with wider filtering ranges, different volume capacities, greater selection of filtering elements and housing materials, and higher pressure ratings. Prices for these custom-built filters may range to $500. Suppliers include: Micrometallic Corp., Puralator Products, Cuno Engineering, Commercial Filters, R.P. Adams.

Pressure regulators

Careful selection often enables use of regulators designed for other services such as welding equipment and medical therapy. For low pressure output (0-15 in. of water), good results can be obtained by modifying a liquefied petroleum gas regulator. Such regulators will handle an input of up to several hundred lb./sq.in. Shown in Figure 2 is a small regulator with ¼ in. NPT inlet and ¾ in. NPT outlet. The top has a hole tapped ⅛ in. NPT so that gases can be piped away safely and a ruptured diaphragm would not create a hazard. Cost of such a unit is less than $25.

For delivery pressures of 5-100 lb./sq.in. and input pressures of 100-200 lb./sq.in., Norgren, Kendall, Conoflow, and Moore regulators have been used. A Conoflow regulator in stainless steel is available for corrosive service. Prices range from $15 to $50.

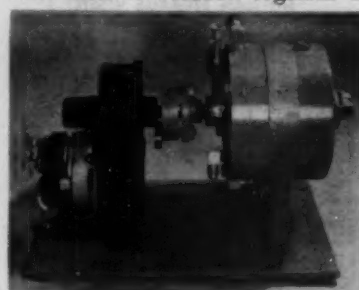


Figure 3. Multi-Way sliding port valve.

For medium pressures (up to 3,000 lb./sq.in. input), regulators made for compressed gas cylinders have proved satisfactory. Makers include Hoke, Airco, National Welding, Victor, Matheson, Bastian & Blessing. Delivery pressure varies widely; some are adjustable over almost the full range of inlet pressures. A cylinder style with ¼ in. NPT inlet and outlet is most convenient for piping into flow panels. For calibration gas cylinders, Mine Safety Appliances has standardized on a 0.906 in. LH external thread

continued on page 124

Gas analyzer

from page 122

connection between cylinder and regulator. The regulator outlet has a ¼ in. NPT outlet. This outlet can be connected to a flow system by any type fitting.

For high pressures, few regulators cost less than $500. Makers include Fisher Governor, Leslie, Grove, Mason-Neilan, and Victor. Maximum inlet pressure is usually 6,000 lb./sq.-in., and the units can be adjusted to deliver 0 to 5,000 lb./sq. in.

When stream pressure is higher than 5,000 lb./sq. in., an orifice can be used to drop the pressure into the range of commercial regulators. Flow must be nearly constant. Upstream pressure can fluctuate from 5,000 to 10,000 lb./sq.in. Downstream pressure must remain above the regulated pressure. A high-pressure "vee" point needle valve may be used as the orifice, or a pilot operated high pressure valve may be used, and the orifice opening set manually to give the desired pressure drop.

For precision pressure regulation, as required on suppressed zero infrared analyzers, for instance, two and even three regulators may be used in series. The input to the final regulator is usually set at about 50 lb./sq.-in. above desired delivery pressure. *Pressure should be dropped as soon as possible in the flow system in order to enable use of lower pressure components, available at lower costs.*

Valves

In flow systems, the most common manual valve type is the needle valve. The "vee" design is excellent for precision flow control, but must not be used for shut off. For shut-off service, a precision valve is recommended, rather than a common steam or water valve; a Teflon seat or an "O" ring seal will give good service.

A plug valve is used for manual selection of several streams. An inexpensive, versatile valve is made by Republic Mfg., in 2, 3, and 4-way types, with ¼ in. tube and larger, in brass or aluminum body, with 50 lb./sq. in. rating. Smaller valves of this type cost about $20; larger ones $75 to $100 and up. The larger sizes are also supplied by Barksdale.

Solenoid valves are used for stream selection, permitting one analyzer to be used on several streams, and for introducing calibrating gases. Such valves are made primarily for pneumatic cylinder operation, and range in price from $15 to $50.

continued on page 126

Gas analyzer

from page 124

To eliminate some of the difficulties inherent in solenoid valves, M.S.A. has developed a "Multi-Way" valve (Figure 3). This is a sliding port valve. Sample lines enter the valve at the flare fittings. A motor-driven inner disc connects one sample inlet with a passage through the center shaft to the flare fitting on the opposite side of the valve body. All other inlets are connected to a bypass connection, maintaining flow through all sample lines, and ensuring fast response. Snap switches can be mounted on the motor shaft to provide a signal for annunciator lights. Timing of sample selection is controlled through motor speed.

Three general types of condensate traps are in use in sample systems. A typical example of the low-pressure trap with no cooling action is the pneumatic tool type filter previously described. Similar units of more elaborate design are available from Selas, Van Products, R. P. Adams. Steam traps for ordinary piping systems can also be used, but most of those available are too large to be suitable.

When the water vapor content of the sample is high, cooling action is needed in the sample system. A long copper tube with fins serves this purpose in many low-pressure systems. For high-pressure systems, flowing water is often used as a cooling medium. If the sample is gaseous, it is often bubbled through a small overflow water bubbler, or passed through a water-jacketed trap.

Before pressure can be reduced in a high pressure system, excess water vapor and particulate matter must be removed. For such difficult problems, where ordinary steam traps cannot be used, instrument vendors (and users) have in many cases designed their own traps. For example, Consolidated Electrodynamics has designed a "Water Coalescer" which will remove up to 10% free water or water vapor from liquid or gaseous hydrocarbon streams; solid particles are not removed. Upper limits of the unit are 200 lb./sq. in. and 200° F. Welded stainless steel water-jacketed conditioners are available for use up to 500 lb./sq. in. and 1,000°F.

A nitric acid and ammonium nitrate plant will be built shortly by California Spray-Chemical, at Kennewick, Washington. The estimated $2 million fertilizer plant will manufacture the ortho line of ammonium nitrate, ammonium nitrate solutions and high analysis nitric phosphate complex plant foods. Expected to begin operation by the end of the year, the facility will supply the company's Pacific Northwest and Rocky Mountain distributors.

The sale of solvent recovery plants discontinued by Union Carbide Olefins (Union Carbide). Columbia activated carbon solvent recovery plants will now be manufactured and sold by Vulcan—Cincinnati, Ohio engineers and constructors. Union Carbide will continue selling Columbia activated carbon for recovery purposes, and will provide technical service for Columbia solvent recovery equipment installed up to the present.

For more information, turn to Data Service card, circle No. 58

Graphite textiles by new process

Graphite fibers and cloth are now being produced by National Carbon Company, offer considerable potential for chemical industry applications.

A process to convert organic textile forms directly to graphite of purity in excess of 99.9 percent has been developed. The manufactured graphite, in flexible fiber and fabric form, is being produced by National Carbon Co. (Union Carbide).

In the process, a fiber or fabric is graphitized by electrically heating it to a temperature approaching 5400°F. In thermo-chemical conversion, the crystalline structure of the material is changed to that of graphite similar to manufactured graphite, producing graphite cloth and fiber.

Properties of graphite textiles are similar to those of the manufactured graphite: Resistance to acids, alkalies, and organic compounds (except those of a highly oxidizing nature). They are unreactive with zinc, aluminum, magnesium, copper and its alloys, and metal producing slags at their melting points.

Most graphite textiles have less than 0.1 percent ash, and for special purposes, it appears feasible to produce graphite textile forms of spectroscopic purity.

Applications

Chemical applications of graphite textiles under consideration are: graphite cloth of proper mesh for bag type filters for hot non-oxidizing gases; for equipment to handle corrosive fluids; in electrostatic precipitators; in curtain walls; and in flame arrestors. Quantities of the cloth are being evaluated as a reinforcing agent for refractory materials used at high temperatures, such as in the nose cones of space missiles. Plastic and refractory materials subject to thermal cycling are also a potential use for graphite cloth. The fibers and fabrics can be used to impart thermal conductivity to non-conducting materials such as plastics, ceramics and glass cloth.

Experimental quantities of graphite fibers and fabrics are now being produced for test and evaluation.

New helium plant planned as helium demand jumps

The fifth Bureau of Mines plant will soon be built, present plans call for the major share to be extracted by private industry

A helium recovery plant, planned by the Department of the Interior's Bureau of Mines at Keyes, Oklahoma, will be the fifth of its kind operated by the Department. Others are already located in Texas, Kansas, and New Mexico, with up to a dozen additional plants under consideration under the government helium conservation program. Because of the missile and atomic energy work in this country, needs for the gas are expected to continue to increase.

Annual consumption of helium has jumped in the last twenty years to an all-time high of 330 billion cubic feet per year (an increase of over 70 percent). At the same time, no new domestic sources have been discovered. About ten times the yearly consumption is now wasted in the normal burning of fuel gases containing helium.

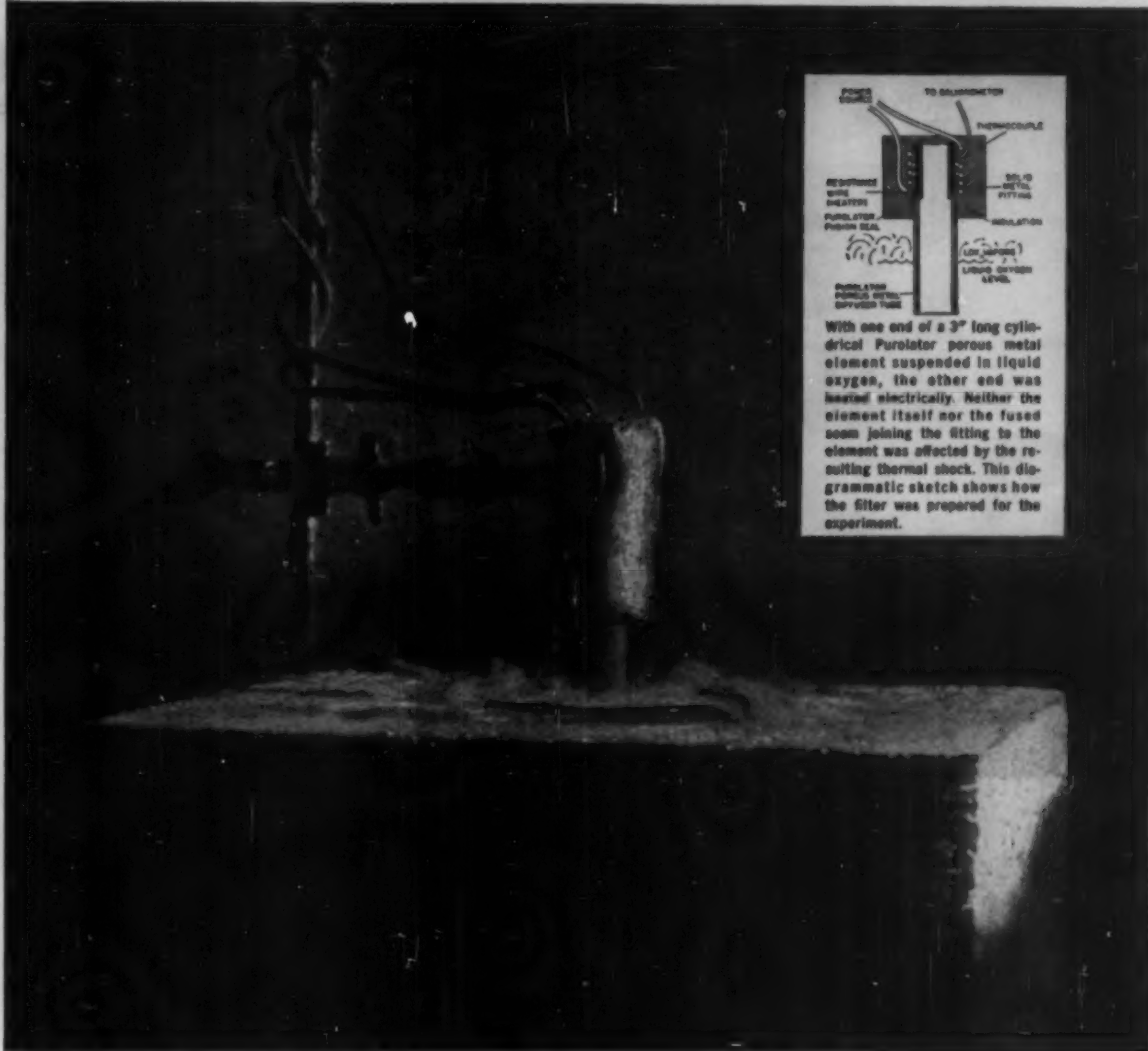
According to present plans, the major share of helium recovered will be extracted by plants built and operated by private industry, then sold on a guaranteed basis to the government. The Keyes recovery operation will be supplied with six large type Cooper-Bessemer gas engine compressors.

In a move prompted by growing interest in molybdenum and tungsten chemistry, six new chemicals have been added to production by Climax Molybdenum (American Metal Climax). The materials are: phospho 12 molybdic acid, silico 12 molybdic acid, molybdenum dichloride, molybdenum trichloride, molybdenum tribromide and tungsten pentabromide. Phospho and silico molybdic acids are distinguished by high solubility in water and ethers, alcohols, and ketones. The dichloride, tungsten pentabromide, and trichloride, have high melting points. They appear to have possibilities as intermediates. Produced at the company's Langeloth, Pa., plant, the metals are available in experimental quantities.

Oxygen production for steelmaking is expected to increase 75 percent at Dominion Foundries and Steel, Ltd. when a new oxton plant goes on stream this summer. Located at Hamilton, Ontario, the $2 million plant will have capacity of 150 tons a day. The new unit, the third built by Dofasco within five years, will bring the firm's total capacity to 350 tons.

Quadruple oxo alcohol capacity is expected by Gulf Oil when a multimillion dollar production plant is completed at its Philadelphia Refinery. The new plant will be primarily geared toward production of isooctyl and decyl alcohols, as well as a broader range of alcohols and other oxo products. Feedstocks for the unit will be supplied from refinery operations at Philadelphia, supplemented by olefinic fractions from other Gulf refineries.

For more information, turn to Data Service card, circle No. 77



Filters for extreme conditions . . .

THERMAL SHOCK

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How much thermal shock can a filter withstand?

In a recent series of experiments, various samples of Purolator metal filter media stood up under temperature gradients, across short lengths, of up to 500°F...and could have taken more. There was no effect on filter efficiency.

Thermal shock is only one of the difficult operating problems Purolator's staff of "Q" and "L" cleared-filtration experts handle regularly. They can design and produce the exact filter needed to remove any known contaminant from any known fluid under any operating conditions. They have produced filters and separators to operate within the following wide ranges of conditions:

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DEGREES OF FILTRATION: from submicronic to 700 microns (in various media).

No other filter manufacturer can offer such complete services to handle so wide a range of tough operating conditions. These brochures outline what Purolator can do for you, or, if you have an urgent filtration problem, call Jules Kovacs, Vice President in charge of Technical Sales . . . or send him the details of your application.

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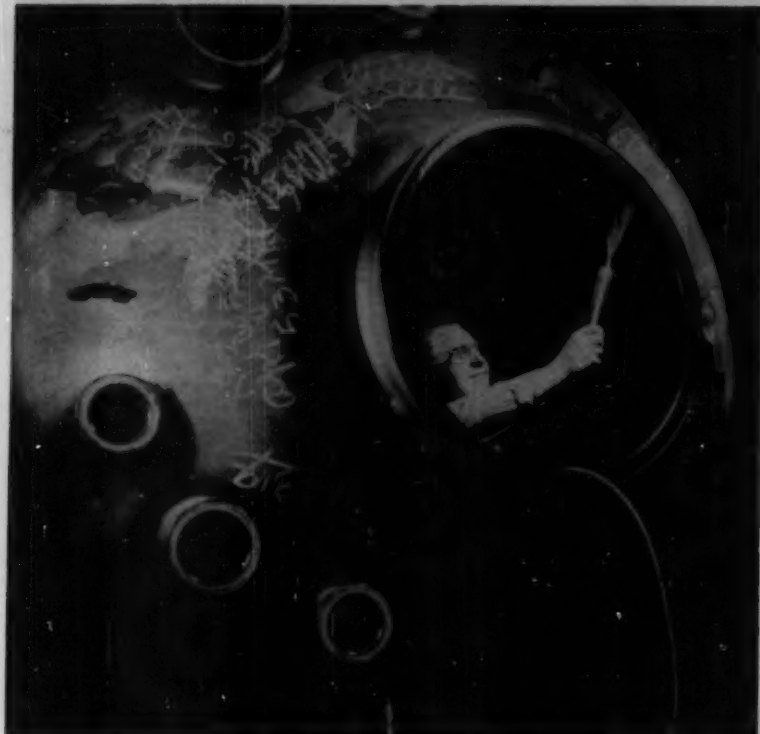
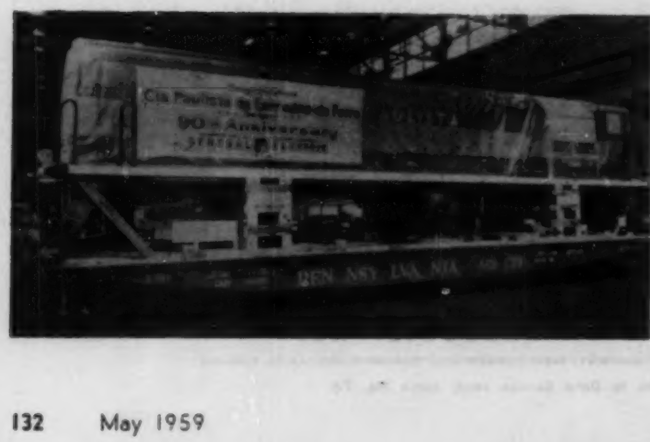
For more information, turn to Data Service card, circle No. 76



A technician at Pfaudler uses the new "Pfaudlertron" to test glass continuity in a large glassed-steel vessel. A constant voltage electronic tester designed for non-destructive testing of surface continuity in glassed-steel equipment, the new instrument is claimed to be absolutely reliable.

Design of the new St. Paul Ammonia Products plant at Pine Bend, Minn., calls for using either natural gas or butane as raw material. Project contractor was the Lummus Company.

This largest titanium head shape ever formed measures 54 inches in diameter, has a thickness of 0.085-inch, and weighs 50 pounds—about 1/2 as much as a comparable steel head shape. Producer is Lukens Steel for Curtiss-Wright Corp.



Probably the first locomotive ever packaged in polyethylene! Being shipped to South America, this locomotive had to be protected. Packaging job was done by Canton Containers, Canton, Ohio.

Encapsulated reactor model, displayed by Babcock and Wilcox, is examined by one of thousands of curious visitors who swarmed through the recent Atomfair at the Cleveland Nuclear Congress. Attendance was good, exhibitors expressed confidence in the nuclear sales picture.

Valves, fittings, piping, from the microscopic to the outsize. This giant example was shown by Crane. Particularly noticeable at the Fair was the increasing use of the rarer metals and alloys in fabrication of chemical processing equipment and accessories.

CLEVELAND MEETING

Arthur Compton speaks at the A.I.Ch.E. luncheon in the Empire Room of the Cleveland-Sheraton.

Robert Gibrat (right), president of Indatom (France), snapped at Cleveland press conference. Left is D. C. Lefebvre of the French Power Bureau, Wash., D. C.

Instrumentation, also, was one of the leading themes of the exhibition. Tracerlab, whose booth is pictured above, was only one of many who unveiled new systems.

Specialized heat transfer equipment for high-temperature nuclear service was also a feature of many booths, including that of Griscom-Russell (above). Here, again, titanium, zirconium, and newly-developed alloys were much in evidence.

ECPD Brochures to aid the young engineer

Two new brochures, *Your First Five Years,* and *Personal Appraisal,* have just been published by the Training Committee of the Engineers' Council for Professional Development. Part of the First Five Years' program of ECPD, they are designed to assist the young engineer in the critical early years of the post-graduate period—when he is finding his place, and establishing his own professional goals.

Your First Five Years outlines the challenge to the young graduate embarking upon an engineering career, cites several guiding principles, and suggests a six-point program consisting of orientation and training in practice, continuing education, professional identification, responsible citizenship, selected reading, and personal appraisal. It is in this period, the brochure says, that the engineer must learn to grow professionally by virtue of his own initiative and perseverance. The suggested program is intended to help him realize his fullest potential as a professional man.

Personal Appraisal, the second in the series, has been issued in a newly revised edition. The 8-page self-appraisal form utilizes the questionnaire method to help the young engineer periodically evaluate himself and his progress in the field. The form, broken down into sections: job, personal, professional, and general program for development, identifies the standards to which a young engineer must adhere if he is to achieve high standing in his profession.

These publications are available, along with *Selected Reading for Young Engineers* (noted in *CEP* April), as separate items, or furnished with each copy of the basic reference manual *A Professional Guide for Young Engineers.*

A 240 ton per day sulfuric acid contact plant is under construction for North Star chemicals at Pine Bend, Minnesota. When completed the end of this year, the plant will be, it is believed, the only sulfuric acid manufacturing facility in Minnesota.

A chemical fertilizer plant at Lukavaz, Yugoslavia, will be built by Montecatini and Ansaldo. The companies have joined forces to supply the technical know-how and equipment at an estimated cost of about $8½ million.

Growth in markets for polyethylene has brought about an expansion of Spencer Chemical at Orange, Texas. The new unit will produce a variety of polyethylene products of low and medium density. Plant expansion is expected to be completed by the summer of 1960.

Comes Nearest to Natural Refrigeration

Nature produces refrigeration (snow, sleet, and hail) indirectly by change of atmospheric pressure to bring warm water vapor in contact with cold air.

XXCl XBr

NO CHEMICAL REFRIGERANT OR ABSORBENT TO LEAK, CORRODE OR CRYSTALLIZE

In each case, water is its own refrigerant or cold air serves the purpose. Jet vacuum refrigeration comes nearest to this natural refrigeration.

As a method of industrial refrigeration, jet vacuum refrigeration is thoroughly established and is successful in many hundreds of industrial plants in capacities varying from a few tons to 4500 tons.

The unit sketched can be placed outdoors and operated continuously or intermittently in any climate. The equipment adapts itself readily to automatic control or is very easy to control manually. The unit is self-supporting. There are no moving parts, no noise, no vibration. The maintenance and supervision required are negligible.

While most vacuum installations are used to cool water, vacuum cooling is particularly efficient for cooling chemical solutions. Instead of the usual expensive heat transfer surface, only simple corrosion-resistant vessels are needed. Some process plants have dozens of separate units totaling thousands of tons of refrigeration just for the purpose of cooling chemical solutions. Their record of savings is remarkable.

There are many other applications, too. Fresh vegetables and other moist solids are readily cooled by jet vacuum refrigeration. By adding a heat exchanger bundle inside the vacuum chamber, gases can be cooled without circulating any liquid. In some cases, the automatic de-aerating effect of vacuum cooling is important.

Many installations of old style mechanical refrigeration could be replaced profitably with vacuum refrigeration, which costs much less to buy and somewhat less to operate.

All inquiries will be given careful engineering study without obligation.

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For more information, turn to Data Service card, circle No. 82

Development contracts for the use of its organic chemicals have been entered into with four leading firms by Meal & Thermit Corp. Goodrich is working with vinyl tin monomers to produce polymers for a new type plastic; the Mobay contract covers the development of catalysts for cellular urethanes used in insulation, and airplane and automobile seat upholstery. The agreement with Dow Chemical covers development of M&T's fungicidal materials for use in agricultural chemicals and water base paints. Permachem is using Tributyltin Oxide in its permachem, the trade name for formulations used as bactericides. Similar formulations are also being used in celanese yarn fabrics to preserve them from deterioration from perspiration.

"Never in the History of science and technology has development and progress been so dependent upon knowledge of the properties of matter as it is today," according to Frederick L. Hoyde, president of Purdue University. He spoke at the opening of the Symposium on Thermal Properties of Gases, Liquids, and Solids, held in February at the University.

Several of the 42 papers presented were on the subject of thermodynamic properties of boron compounds. Also included was Mollier Enthalpy-Entropy Charts for High Temperature Plasmas.

The 4-day session, sponsored by ASME Heat Transfer Division, in cooperation with the University's Thermophysical Properties Research Center, was attended by 150 scientists and engineers.

A course in "Advances in Chemical Engineering" will be offered at the University of Michigan this summer, according to tentative plans just completed. Eighteen other classes, in addition, will be given as part of the Engineering Summer Conference at the University. The intensive non-credit classes (each one runs for a period of under two weeks), are designed for practicing engineers and scientists. Several classes cover the subject of computers comprehensively. Among these are: Introduction to Standard Methods of Numerical Analysis, Advanced Theory of the Logical Design of Digital Computers, Computers Programming and Artificial Intelligence.

The development of power reactors using nuclear superheated steam is contemplated by ACC. The commission has invited proposals from industry for a program which will include the development of fuel materials and methods of steam separation and heat transfer. Advantages, it is felt, are in possible reductions in fuel cost brought about by increased plant efficiency due to higher steam temperature. Also a simplified turbine and associated equipment might be made possible by use of dry steam at the turbine.

The Zirconium Association has been formed by a group of sixteen companies that produce, melt and process zirconium. Purpose is to expand uses of the metal and establish a center from which to develop cooperation between industry and governmental agencies. Offices of the association are in Cleveland, Ohio.

An A.I.Ch.E. Technical Manual

Bubble-Tray Design Manual

prediction of fractionation efficiency

by the Distillation Subcommittee of the Research Committee

• Enables the engineer to predict efficiencies for commercial bubble trays used in multicomponent fractionation. • Contains sample calculations made on plant-scale columns. • Includes calculation form sheets for the use of the reader. (Additional sheets may be purchased.)

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Hard covers, gold stamped, 6⅛" x 9¼", 94 pages, attractively designed and printed.

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Member ( ) **Non-member ( )**

New-type molecule seen stepping stone to heat-stable plastics. New compounds of boron and phosphorus, christened "phosphinoborines," have been synthesized in the labs of American Potash & Chemical. The newly-synthesized molecules, described as a "linear chain of repeating, tetracoordinate phosphinoborine units," with a high molecular weight of about 12,500, may, it is claimed, lead to development of plastics capable of resisting temperatures up to 750°F.

Proposals for the building of nuclear power reactors in Europe were considered when the US-EURATOM Joint Research and Development Board met in April. The proposals were invited under the Agreement for Cooperation between AEC and EURATOM (European Atomic Energy Community) which went into effect early this year. It contemplates a joint research and development program with its main objective to bring into operation large scale power plants using nuclear reactors developed in the United States. Operating conditions would approach the range of conventional energy costs in Europe.

Closed-circuit television was used extensively at the recent Geneva Conference on the Peaceful Uses of Atomic Energy. Sets, strategically located around the Exhibition, showed French and English versions of the technical discussions at the Palais des Nations.

A corporation in the Bahamas, Hooker Chemical International, Ltd., has been formed by Hooker. Purpose is manufacturing and marketing activities in Latin American Countries. Hooker Mexicana has also been formed primarily to manufacture phosphates in Mexico.

A one-day school for chemical engineering teachers will be conducted by Standard Oil of Ohio this fall. Announcements for the sessions, which will take place at Sohio's recently completed integrated refinery in Toledo, Ohio, on October 16, have already gone out to the participating colleges. Clyde Bruggers, of Sohio, is in charge of the school.

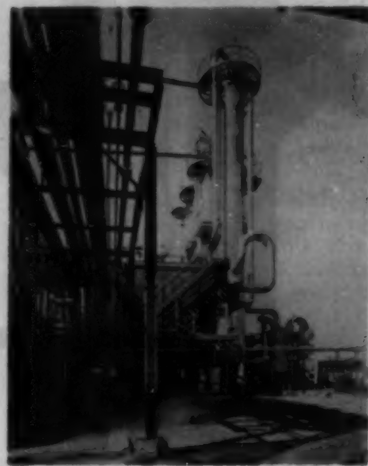
Quadruple startup in ethylene oxide

Four plants in three countries are placed on stream by Scientific Design within one month period.

In the space of thirty days, Scientific Design Co. of New York has put into operation four ethylene oxide plants in three different countries: Jefferson Chemical's plant at Port Neches, Texas; Societe Chemique des Derives du Petrole's at Antwerp, Belgium; Chemische Fabrik Holten's at Ludwigshaven, Germany, (the company is a subsidiary of Badische Anilin & Soda-Fabrik, Ruhrchemie Aktiengesellschaft, and Th. Coldschmidt); and Erdoelchemie's at Dormagen, Germany, (a subsidiary company of Farbenfabriken Bayer, The British Petroleum Co., Ltd.).

Contracts have also been awarded, says Scientific Design, for three new ethylene oxide plants. The buyers: Erdoelchemie, Dormagen, Germany; Societe Chimique des Derives du Petrole, Antwerp; and Naphtachimie, Lavera, France. All are repeat customers.

The new Erdoelchemie plant will be adjacent to the unit just commissioned. The two units together, with a combined capacity of about 79 million pounds a year, will constitute, it is believed, the largest ethylene oxide plant outside the United States.



Ethylene oxide plant just placed on stream by Erdoelchemie, Dormagen, Germany.

For Societe Chimique des Derives du Petrole, and Naphtachemie, the new plants, to be on stream by 1960, will double existing capacities. All of the plants use SD's direct oxidation process.

Largest sea water distillation plant

New $11 million Aruba plant combines sea water conversion with production of surplus electric power.

Said to be the world's largest single installation for converting sea water to fresh, a new distillation plant in Aruba, D.W.I., is now turning out some 2.7 million gallons of distilled water per day, plus a surplus of 15,000 kilowatts of marketable electric power. The process combination, says Singmaster & Breyer, designers and builders of the plant, may point the way to lower prices for converted sea water in many parts of the world. A large installation of this type could, under favorable circumstances, produce fresh water for as little as $1.00 per 1,000 gallons, claims S & B, assuming a credit from power sales. (Initial cost estimate for the Aruba unit is $1.75 per 1,000 gallons).

Five independent lines of sextuple-effect evaporators are used at Aruba, each with a capacity of 540,000 gallons per day. Source of energy is heavy residual fuel oil from the local Lago refinery. Steam from two Babcock & Wilcox 200,000 lb./hr. boilers (one a standby), operating at 875 lb./sq. in. and 820°F, enters two turbo-generators, each rated at 7,500 kilowatts at 0.75 power factor. Boiler makeup is distilled water from the evaporators.

Special descaling system

Key to plant efficiency is said to be use of the "Scalemaster," a process developed and supplied by G. & J. Weir Ltd. (Glasgow, Scotland), who also furnished the evaporators. The method is based on a ferric chloride treatment which keeps dissolved cal-

continued on page 142

New carbon black synthetic rubber

Fifteen percent more road life claimed by Goodrich-Gulf Chemicals for new tire tread material now in volume production at Port Neches, Texas

On stream at the Port Neches, Texas, plant of Goodrich-Gulf Chemicals is 15 million pounds a month capacity for production of a new cold rubber containing an intimate mixture of carbon black. Half of the existing styrene-butadiene copolymer lines at the Port Neches plant have been converted to the new production, along with their recovery and drying equipment. Cost of the switch-over: about $1¼ million.

Used as tire tread and retread stock, the new material is claimed to have up to 15% more road life than present synthetic rubbers. Secret of the process, according to Goodrich-Gulf, is hydraulic injection of slurried carbon black into a turbulent stream of liquid rubber; present practice is dry mixing of the reinforcing agent. The added tread life is said to have been substantiated by road tests conducted by several tire manufacturers.

World's longest zipper

Feature of the Port Neches installation is the handling equipment for the large amount of carbon black required. Unloaded from railroad cars,

continued on page 140

Zipper belt conveyor, more than 500 feet long, carries carbon black from railroad cars to storage silos at Port Neches, Texas, plant of Goodrich-Gulf Chemicals.

Synthetic rubber

from page 138

the powdery material is discharged into a zipper belt conveyor more than 500 feet long. The belt, made by B. F. Goodrich, is automatically closed into a tube by rubber zippers as it leaves the unloading zone. After grinding, the carbon black is slurried and injected into the liquid rubber. Addition of a coagulant (acid) produces instantaneous blending. After conventional filtering and drying procedures, the "Ameripol Micro-Black" masterbatch is compressed into standard bales.

Besides tire treads, other uses foreseen by Goodrich-Gulf for their new rubber include belting, insulations, and molded and extruded products intended for heavy duty service.

Licenses for the sea disposal of low-level radioactive wastes are proposed by AEC for two New England firms: under the proposed permits, Walker Trucking Co., New Britain, Conn., would be authorized to dispose of waste by-product material (radioisotopes) and waste source material (uranium and thorium); New England Tank Cleaning Co., Cambridge, Mass., would handle by-product material. Each firm would be authorized to collect pre-packaged waste materials from Commission-licensed users, and to dispose of the materials in the Atlantic Ocean in containers heavy enough to ensure sinking to at least 1,000 fathoms (beyond the Continental shelf).

Use of sodium reactor coolant as a high-level radiation source for industrial processing will be studied by Atomics International, under contract to AEC. The proposed study will include not only the feasibility of using the sodium coolant for industrial processing purposes, but also the possibility of integrating such a radiation processing plant with the nuclear power facility now under construction at Hallam, Nebraska. Full power operation of the 75,000 net electric kilowatt Hallam plant, being built by the Commission and the Consumers Public Power District, is expected in late 1962.

Construction of a new bulk sulfuric acid terminal started by Dixon Chemical at Fall River, Mass. The terminal will have a storage capacity of 3200 tons and blending facilities to make any grade of sulfuric acid.

For more information, turn to Data Service card, circle No. 102

Sea water

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cium and magnesium salts in solution.

Two streams leave the distillation system of the plant: the waste brine at 130°F and about 75,000 ppm salinity, which is pumped back to the sea; and the distillate, which contains less than 5 ppm of solids. This distillate is split into two streams, one for municipal consumption in Aruba, and one for the Lago refinery. The stream intended for Aruba has its low pH (about 5.5) corrected to 7.2, and its taste improved by passage over coral limestone and by aeration. It is then chemically treated to raise its pH to 8.3, filtered, and stored for distribution.

Rights to the production of acetylene and ethylene under a large group of patents relating to the Wulff process have been acquired by Wulff Process Company. Purchase was made from Lummus, Koppers and Fluor. While basic rights to the process are owned by Wulff, these agreements bring together improvements developed by the above firms. Therefore, licenses of the process can take advantage of latest techniques in regeneration, cracking and gas separation and purification developed in connection with the process. Also concluded are agreements covering engineering and construction of Wulff plants throughout the world by Lummus, Fluor and Koppers.

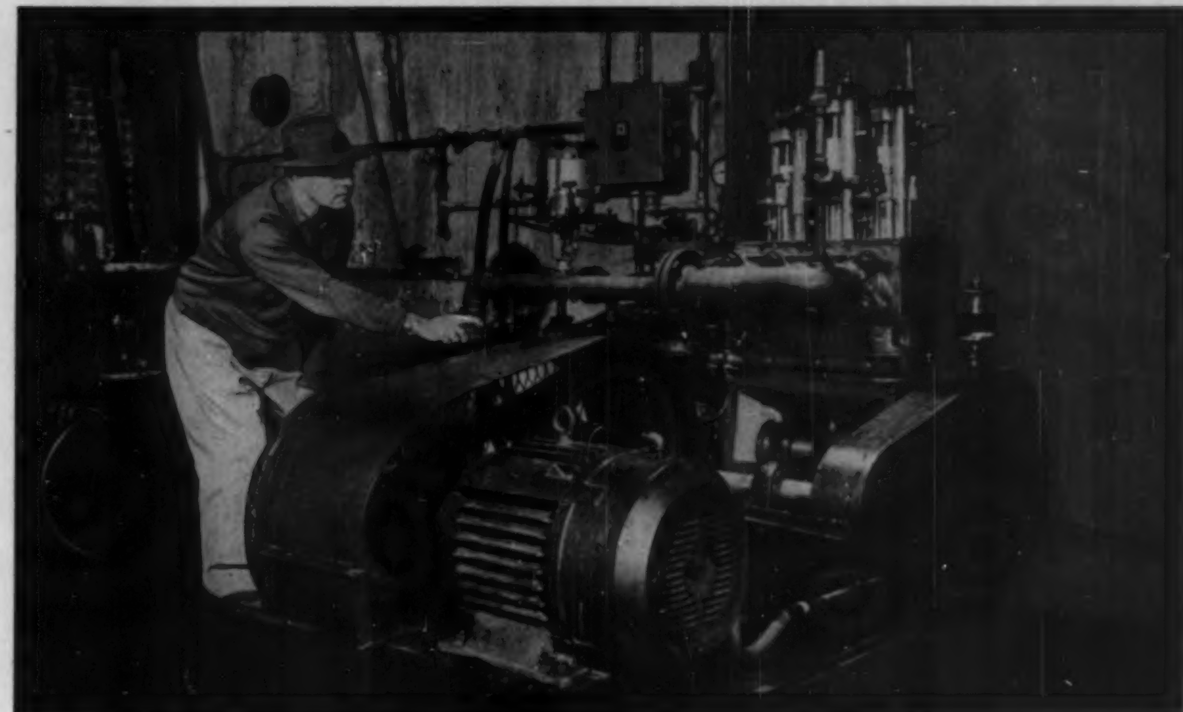
A new geothermic source of energy has been located on the slopes of Mount Amiata, in Italy. The So. di Larderello, which operated the geothermic resources of the same name, has, after a year of study, thought in similar endogenic forces in one of Italy's most important mining areas. The steam jet exploded at less than 1000 feet. Pressure is estimated at 6000 kilograms and temperature ranges between 140 and 170 centigrades.

To acquaint the engineer with methods of applied research management in industry is the goal of a new graduate evening course being offered this fall in the chemical engineering department of the Illinois Institute of Technology. Dealing with supervising personnel, organizing a staff, preparing budgets, planning research programs, and evaluating the results of research, the course will emphasize the smaller groups in large laboratories and medium-sized research departments.

JACQUES WOLF & CO. SOLVES PROBLEM:

How to maintain constant, undeviating pressure in the production of highly corrosive chemicals

Precise, non-fluctuating pressures must be maintained in continuous processes at the Carlstadt plant of Jacques Wolf & Company. Erratic pressure caused by drop in volumetric efficiency could ruin an entire batch of costly material.



How Jacques Wolf solved the puzzle: Looking for an answer to the problem of holding constant pressure, plus that of increasing production, Jacques Wolf called on Aldrich. Aldrich engineers designed a pump which provided the proper corrosion resistance, fluid velocity and wear characteristics to insure dependable, continuous operation.

Result: After five months of use, the Aldrich Triplex Pump has met all guarantees and proven itself capable of continuous operation. Working 24 hour days, 6 day weeks, the Aldrich Triplex Pump provides the necessary pressure without fluctuation, efficiently handling both alkaline and acidic materials.

We'll be glad to send you full information on Aldrich Pumps and their advantages to you. Simply write Aldrich Pump Company, 20 Gordon Street, Allentown, Pa.

the toughest pumping problems go to ALDRICH

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Philadelphia-Wilmington One-day Meeting

At the Philadelphia-Wilmington one-day meeting, M. L. Thorpe, Thermal Dynamics Corp., graphically illustrates the operating range of the plasma torch at the session on Plasma: High Temperature Heat Source. At right is R. E. White, Villanova University, presiding chairman of the morning session.

A battery of seven experts from as many fields undertook to describe "New Advances in Chemical Engineering Practice" to an attendance of over two hundred at the **Philadelphia-Wilmington Section** *(D. G. Evans)* Seventh Annual All-Day Meeting at the University of Pennsylvania, March 31. This year continued the *Experience in Industry Symposium* initiated to give younger members of the profession an opportunity to share the practical experience of successful engineers.

Richard Fleming, Sun Oil, chaired the affair, which got under way with M. L. Thorpe describing the advent of the plasma flame, which can produce temperatures several times that of the oxyacetylene flame, and can fuse and vaporize all known materials. Several plasma producing devices all employ the same principle, an electric arc passing through a constrained region which serves to stabilize the arc. Stabilization is effected either by the low density core of a vortex flow, or by wall-stabilization technique. Some applications of this heat source are: natural gas reformation, carbon black manufacture, free radical source, growth of crystals, missile re-entry simulation, and wind tunnels.

R. H. Jebens, Patterson Foundry and Machine, reviewed the status of solid mixing equipment, pointing out that while there is no single blender design which is universally acceptable because diverse factors enter into selection of a blender, most requirements of each application can be met by modification of standard designs. Addition of a disintegrator blade to a double cone blender, or use of two speed drive for this apparatus, were cited as examples.

Recent advances in biochemical technology from the chemical engineering viewpoint were explored by E. L. Gaden, Jr., Columbia University. Most important difference between biochemical processes and their more conventional chemical counterparts, is the special nature of enzyme catalysis which most biochemical reaction systems require.

D. E. Boyton, Hercules Powder, talked on advances in reactor design. The great number of concepts which should be considered simultaneously in designing a reactor can now be handled on computers. Extraction and distillation columns, and the engine reactor, are important. Except where

high rates of heat transfer and ease of solids handling are important, growth is not expected in the area of fluidized beds.

Other papers presented at the meeting covered "mini-plants", saline water utilization, and overall trends in chemical technology. J. A. Knaus, Kellogg Co., discussed the role of the "mini-plants" in pilot plant programs. Factors such as justification of expenditure, scale-up reliability, quantities required for evaluation, literature data available, and unit operability, must be considered in setting pilot plant size.

According to O. M. Elliott, Sun Oil, water supplies should be used as they exist, rather than attempts made to convert them to pure water. No immediate prospects exist for desalting sea water economically on a large scale. For partial desalting, ion membrane techniques are economical.

A. Pechukas, GE, summarized the material user's view of industrial trends in the United States. Particularly significant is increased dependence upon imported raw materials, intensified competition from overseas manufacturers, and technological growth.

Professionalism, modern fuels

Legislative action and licensing procedures are not the way to attain professionalism for engineers, in the opinion of D. A. Stokes. The vice-president of Texas Butadiene and Chemical Company addressed the final session of the Joint Technical Meeting of the **Sabine Area Section** *(Norman Wacks)* and the Texas-Louisiana-Gulf Section of ACS on March 13. Stokes takes the position that professionalism can be achieved through the establishment of high standards of professional attainment by members of the appropriate professional societies.

The 12-paper all-day meeting was attended by over 350 people, the largest number of participants since the annual series was instituted six years ago.

Highlight of the gathering was a symposium on modern fuels. Covered was: *Hydrotreating for Superior Jet Fuels and Kerosenes,* led by G. T. Gwin, Humble Oil and Refining; *110 Octane Fuel from Commercial HF Alkylation Unit,* E. K. Jones, Universal Oil; *High Energy Aviation Fuels, from the Petroleum Industry and its Relatives,* R. A. Wells, Gulf Research

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and Development Company; *Anti-static Agents for Jet Fuels,* R. A. Burdette, Shell Oil.

Economic evaluation

The need for economic analyses as supplements to engineering studies was under discussion at the **Maryland Section** *(Philip Messina)* in February. James B. Weaver, manager of economic evaluation at Atlas Powder, gave economic evaluations required in the chemical field for the following various reasons: introduction of a new product, expansion of an existing facility, removing a process bottleneck, equipment replacement without any expansion of production, substitution of new types of equipment for existing facilities.

The **Maryland Section** also participated in an Engineers' Week dinner meeting, along with SPE and other affiliated technical societies. Ninety students from high schools in the state who have excelled in studies of scientific subjects were honored. The group heard Alexander C. Monteith, vice president of Westinghouse, talk on *Engineering in the Space Era.*

A professional person must accept the obligations of one. In the world today you are either an aid to the solution of the world's problems, or you are a part of the problem, said Clark A. Dunn, president of NSPE to the **Bartlesville Section** *(R. C. Harrison)* February meeting. The first contribution an engineer can make to world peace is to aid our nation to maintain a healthy economy, he continued. Also, in nations less industrialized than ours, much assistance of an engineering nature is needed. But in too many instances, we have provided funds or finished products rather than assistance in solving the country's problems. We must help them to help themselves. Of equal importance with the specific physical accomplishments, is the manner in which these tasks are performed. The engineer must not ignore the social customs, or become scornful of the people he is attempting to help, or he may create more problems in our relations with other nations than he solves.

Fund campaign success

Subscribing 135 percent of its quota in the fund campaign for the United Engineering Center, the **Ohio Valley Section** has become, along with four other founder society sections in Cincinnati, first in the country to go over

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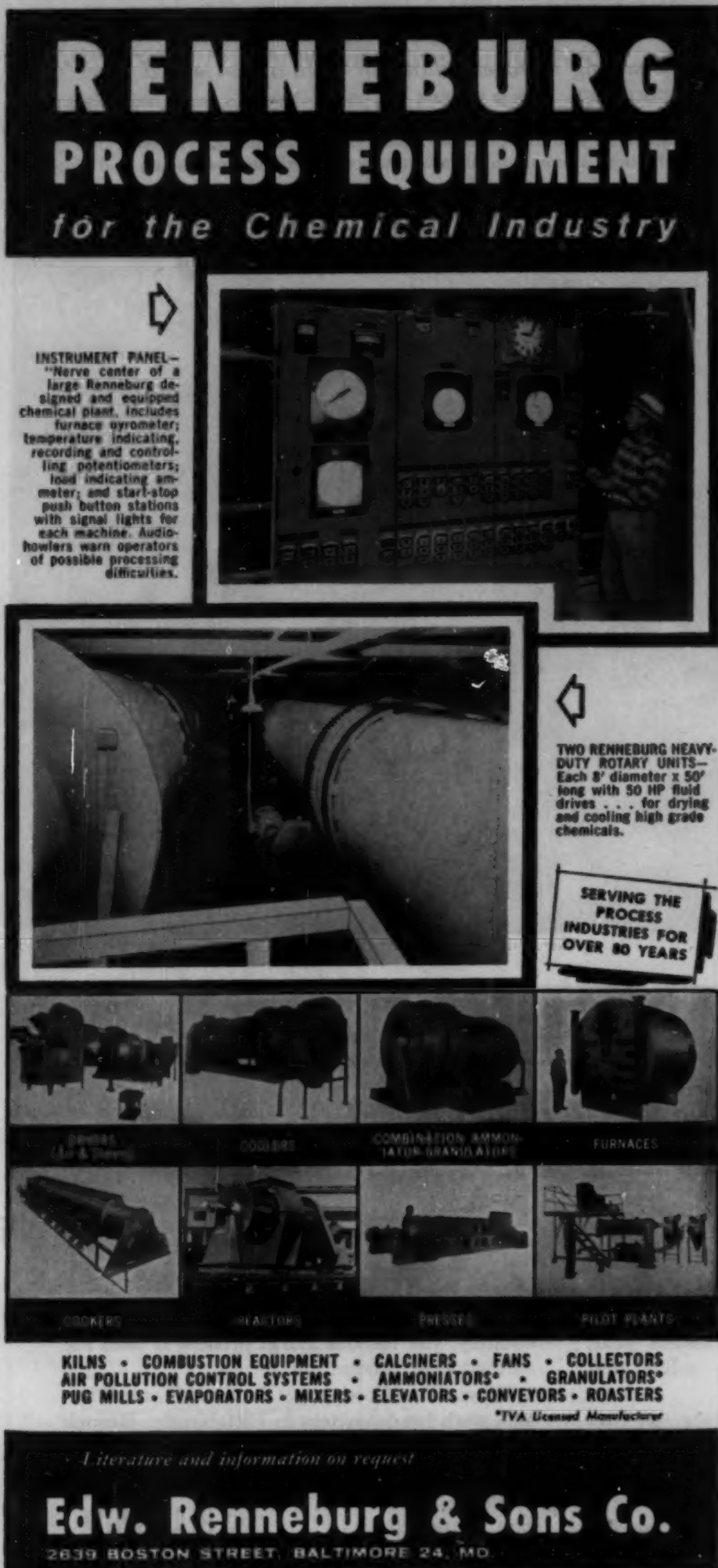

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the top. One hundred and sixteen members of the section contributed $4,325 to the drive. Kenneth Pettengill, chairman of the Ohio Valley Section, represented A.I.Ch.E. on the sponsoring committee of the local campaign. Although minimum quotas in the campaign have been reached, the effort to reach all members of the Founder Societies who have not pledged continues.

Ernest B. Fields, president of Cincinnati Gas & Electric, was chairman of the sponsor group which led the member gifts campaign in Cincinnati, and is shown being presented with a token of appreciation by the local section representatives. L. to r. C. Wandmacher, ASCE; J. E. Tobey, AIME; Fields; L. L. Bosch, ASME; K. H. Pettengill, A.I.Ch.E. chairman of the Ohio Valley section; W. A. Farris, AIEE.

Also meeting

The pros and cons of professional registration are still of interest, as evidenced by the March **Western Massachusetts Section** *(A. W. Andrews, Jr.)*. The meeting listened to Walter Kreske, a national director of NSPE, who helped formulate the legislation in Massachusetts, on "The Current Status and Future Trends in Professional Registration." . . . The **New Jersey Section** *(R. J. Boyle)* heard Peter D. Moskovits on the opposition side of the subject. According to Moskovits, the public neither knows nor cares about whether the engineer is registered or not. Professional society certificates are at least as good as state board equivalents. . . . In the field of heat transfer, Donald Q. Kern addressed the **Rochester Section** *(Arthur S. Diamond)* in December. The talk, on *Mechanically Aided Thermal Processing*, was originally delivered by Kern at the Joint A.I.Ch.E.-ASME Heat Transfer and Fluid Mechanics Conference at Edgewater Beach, Florida, in the summer of '58. In

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January, the section heard R. H. Wilhelm analyze *Transport and Mixing Operations* in view of recent studies on the intermixing of miscible streams. . . . An uncommon combination—that of sculptor and chemical engineer. Harvey Moore is both. He spoke to the **National Capital Section** (*V. A. Wente*) in January, about "Sculpture Metal Casting and Engineering". Included were descriptions of some unusual metallurgy and chemical effects. . . . A general description of cathodic protection as a weapon of the corrosion engineer, as well as a demonstration of the thermite welding used in cathodic work, was given the **Alton-Wood River Section** (*Charles E. Knipping*) in December. Speaker was C. W. Ambler, corrosion consultant. . . . New uses and developments in conventional filtration equipment, such as the pressure centrifuge, were touched upon at the **Pittsburgh Section** meeting in January (*V. N. Hurd*). P. L. Stavenger was the speaker. His topic: New Tools for Liquid Solid Separation. . . . Programs in the field of controlled thermonuclear research throughout the world were outlined by Henry Hurwitz of GE before the **Northeastern New York Section** in January (*W. L. Robb*). Some of the problems which must be solved in order to prove the technical feasibility of controlled thermonuclear power, were also touched upon. . . . Boron and its role in high energy fuels from the engineering standpoint was discussed by E. A. Weilmuenster at **Western New York Section** in January (*Reed E. Garver*). Weilmuenster is in fuels research at Olin-Mathieson. . . . **Charleston Section** (*N. R. Kouba*) heard Arthur Stosick, a member of the Department of Defense's Advanced Research Projects Agency, describes the performance characteristics and limitations of chemical propellants. The chemical limitations of both hydrocarbon and non-hydrocarbon fuels were considered. . . . **Detroit Section** (*John Tourtellotte*) held its annual Ladies' Night in February, with an address by Minoru Yamasaki on architecture in relation to society. The way in which he develops this relationship in his work was explained by Mr. Yamasaki. . . . **Northern California** (*William B. Hauserman*) departed from the beaten track at the January meeting with a discussion of the proposed public transportation system in the San Francisco area. . . . **South Texas** (*W. G. Domask*) in February, took a look at the question of patentable ideas, how engineers and companies are obligated to one another under employment contracts, and how an engineer can get a release to market his patent elsewhere. Authority on the subject was J. W. Hayden, chemical engineer and patent attorney. . . . Ladies' night at **Philadelphia-Wilmington Section** (*George F. Nahill*) traced the development of perfumes from their earliest appearance in Egypt before 3000 B. C. to the present. Lecturer was Oliver Marton, chief perfumer for Shulton. . . . At the **East Tennessee Section** (*James E. Williams*) Porous metal filters and applications of these was the topic discussed in January. Stanley Sakol of Pall Corp. Micro Metallic Division described applications of these materials.

For more information, turn to Data Service card, circle No. 89

Best Paper Awards
— Cincinnati and Atlantic City

John M. Prausnitz (above) received the award for the best paper presented at the Atlantic City National A.I.Ch.E. meeting. Prausnitz, a faculty member in the Chemical Engineering Department at the University of California, prepared the paper jointly with P. R. Benson, also of the University. Titled *Solubility of Liquids in Compressed Gases*, it dealt with solubilities of several liquids measured in compressed hydrogen, nitrogen, and carbon dioxide at two temperatures and at pressures up to 100 atm. According to Prausnitz, the results of the study were interpreted with the virial equation of state, whose coefficients are directly related to the theory of intermolecular forces. The analysis gives a correlation in terms of effective collision diameters which can predict gas-liquid equilibria for a variety of operations, such as high pressure absorption and Hydrofining.

The 30-year old educator has been at the University of California since 1955, the year he received his doctorate from Princeton.

Cincinnati Winners

In a departure from established policy, **W. H. Darnell** and **Marvin L. Katz** were both named by the presentation award committee of the Cincinnati Annual Meeting for outstanding papers. Each of the two men, in a tie for first place, was recipient of an award for his presentation. Katz, who is at the University of Michigan, delivered a paper on the *Effect of Thermal Cycling on the Heat Transfer Performance of Integral Finned Duplex Tubes*. An abstract of the paper, written jointly with Edwin H. Young, appeared in the April issue of CEP. Darnell, who is with Du Pont, took as his subject *Drop-size Distributions from Pressure Nozzles*.

George H. Scheffler, with his appointment as research associate, Chemical Research Department, Atlas Powder, assumes responsibility for work on Darco activated carbons for the Wilmington, Delaware, firm. With Atlas since 1930, Scheffler was one of the original men assigned to the lab, then at Tamaqua, Pa. **Richard B. Hoots** succeeds to his post as manager of the Darco Experimental Laboratory at Marshall, Texas. He moves up from assistant manager.

Granville M. Read, chief engineer at Du Pont for the past thirteen years, retired after a 43-year career. Read inaugurated the "Year-in-industry program" under which engineering educators spend a year as members of Du Pont's Engineering Department. His professional honors include the annual SME medal for distinguished service in 1955. He was also named Delaware's Engineer of the Year by NSPE, in 1957. Read is a director of the Remington Arms Co., Du Pont subsidiary. Melvin F. Wood moves up from his post as assistant chief engineer to succeed him. Wood joined Du Pont in 1928 as assistant construction superintendent in the department, and has spent most of his years with the company in various executive posts in the same department.

Lawrence M. Roberts takes on the position of senior vice president of Research - Cottrell. Roberts will also continue his duties as head of engineering and research, and as a director at the Bound Brook, N.J. firm.

George C. Szego joins Space Technology Laboratories as a member of the technical staff. Prior to his new affiliation, Szego was manager, space propulsion operation at GE in Cincinnati, Ohio. His work at Space Technology will include research on advanced energy sources and propulsion systems in the special projects office.

James W. Evans elected vice president in charge of research of American Maize-Products. He moves up from the position of director of research at the Hammond, Indiana, laboratories of the company.

Arthur Weinberg becomes vice president and group manager of the Public Relations Department, at G. M. Basford, New York industrial advertising and public relations agency. Weinberg has a Ph.D. in Chemistry, and formerly lectured at the School of General Studies at Columbia University. He was assistant editor, *Chemical Week* magazine, and a member of the news bureau at GE Chemical Division.

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Gerald Thomas MaGee has received the 1959 A.I.Ch.E. Scholarship Award at the University of Missouri. The award is given to the member of the student chapter of A.I.Ch.E. who receives the highest scholastic rating, and for participation in other activities during the first two years of college. MaGee, a sophomore, is highest in scholarship in the entire college of engineering.

H. E. Robinson elected vice president in charge of Swift & Co. scientific research activities. He succeeds R. C. Newton, who is retiring. Robinson joined the Swift research staff in 1932, and has been director of laboratories since 1953. Prominent also in government research projects, he is at present on the organizing committee for the International Nutrition Congress to be held in the US in 1960.

Lt. Gen. James M. Gavin (ret.) elected executive vice president of Arthur D. Little, Inc. The former Chief of Army Research and Development had been in charge of the consulting firm's regional offices and management services division.

Saul Ricklin appointed director of development for the Dixon Corp., Bristol, R. I. firm. He was formerly owner and president of Ricklin Research Associates.

E. Clarence Oden goes to Petrobras, in Rio de Janeiro, Brazil, for the next two years. He will act as consultant and professor to a group of college graduates in training to design and operate petroleum refineries and petrochemical plants in Brazil. Oden, formerly head of development for Chemstrand, is a former chairman, Tennessee Valley Section, A.I.Ch.E.

Newton E. Armstrong appointed manager, Systems Development Division of Southwestern Industrial Electronics Co., (Dresser Industries). Armstrong, who joined DIE in 1957, was until recently product manager, Control Division. He was previously with IBM in Endicott, N. Y.

Lyman H. Allen, Jr. appointed engineering and maintenance manager of Fiber Industries. Inc., new firm jointly organized by Celanese and Imperial Chemicals. Allen has been with Celanese since 1951, most recently at the Fibers Division headquarters Central Engineering Department. He has served in a number of engineering capacities for the division, and on various foreign projects. Allen's offices at the new plant will be in Shelby, N. C.

William L. Swager named assistant manager of the Department of Economics at Battelle Memorial Institute, Columbus, Ohio. Since joining the research center's staff in 1948, Swager has devoted much effort to economic studies of the chemical industry.

Richard F. Buchholz promoted to superintendent of manufacturing technical services at the Ethyl plant in Baton Rouge, Louisiana. Buchholz, associated with Ethyl since 1951, has been acting superintendent since 1958, and was previously engaged in process design and economic evaluation studies for the company.

Key additions to the staff of Dixon Chemical are **Arthur G. Walsh,** Director of engineering, and **Irwin S. Zonis,** supervisor of chemical engineering.

Stanley Kubu takes over as assistant director of engineering in Corn Products Co., Technical Division, Argo, Illinois. Kubu, associated with Corn Products for fourteen years, heads the process engineering group, Chemical Engineering Department.

Wayne T. Davis joins Ethyl Corp., Baton Rouge, La. He received an MS from Louisiana State University.

Norman B. King a new member of Badger Mfg. staff. He is a process engineer at the Cambridge, Mass., firm.

Allied Chemical appoints **Roy Meiklejohn** director—western operations. Offices are in San Francisco, California.

One of the first Engineers' Day Honor Awards presented to **Frederick B. Langreck** by the Washington University School of Engineering, St. Louis, Missouri. Langreck is technical advisor to the general manager, Research and Engineering Division, Monsanto Chemical.

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Henry J. Masson retires as assistant dean in the Graduate Division of NYU's College of Engineering. Masson, who was named professor emeritus upon his retirement from teaching duties in 1957, joined NYU's staff 41 years ago. He is considered largely responsible for founding the Department of Chemical Engineering at the college, and was first chairman of the department, as well as first director of the Graduate Division. Masson has also been active in petroleum technology. He holds several patents, and has served in addition as consultant to the industry.

Addition to the staff of The Carwin Company in North Haven, Conn., is **L. Eugene Greenwell,** as project manager. He was most recently with Monsanto.

Vincent W. Haedrich takes over as technical director, Development Engineering Division, Du Pont Engineering Department. He succeeds Charles E. Daniels, recently appointed assistant chief engineer.

Carl W. Weil moves over to the position of assistant manager, Bridgeville, Pa. plant of American Cyanamid, Plastics and Resins Division.

George C. Krusen II joins the Process Development Department, Dewey and Almy Chemical Division, (W. R. Grace), as development engineer. Krusen served with Bay State Abrasive Products Co., and Davison Chemical division of Grace Co.

Production manager at Chas. Pfizer, Groton, Conn., plant is **Stanley W. Ensminger.** Ensminger has been with Pfizer since 1943. He assumes direction of fermentation, clarification, and antibiotic recovery departments.

Recently retired is **Wilfred M. Bywater,** a 42 year veteran with Allied Chemical Plastics & Coal Chemicals Division. He was administrative supervisor in the Research and Development Department.

James Gorman, manager of nitrogen products for American Cyanamid's Agricultural Division since 1944, steps down after 32 years with the company. **C. Paul Schafer** named to succeed him.

Roger L. Sullivan promoted to production suprintendent of Becco Chemical Division, Food Machinery and Chemical, Buffalo, N. Y.

Maynard L. Parker moves up to the post of works manager at Hooker Chemical, Niagara Falls, N. Y. plant. He was vice president in charge of production at Oldbury Electro-Chemical until the firm merged with Hooker in 1956, when he was named production manager Oldbury Products. Another change at Hooker involves **Thonet C. Dauphiné**, who moves over to a position in the general development department, specializing in economic development.

Raymond Wynkoop takes over as manager of basic research at Sun Oil. Opening was created when **Abraham Schneider** became research scientist in the Research & Development Division of Sun Oil at Marcus Hook, Pa.

The appointment of **Willard F. Libby** as professor of chemistry at UCLA becomes effective in July. Libby, the first chemist to be a member of the Atomic Energy Commission, had been on leave from the University of Chicago's Institute for Nuclear Studies. He is the recipient of ACS's Willard Gibbs medal, and is best known for his studies of carbon 14 and tritium.

Chris A. Stiegman takes over the position of director of research at Hooker chemical. His offices will be located at the Research Center at Grand Island (Niagara Falls), N. Y. In another company change, **Robert E. Noble** was made assistant general manager of the Phosphorus Division in Jeffersonville, Indiana.

David L. Matthews selected manager of manufacturing of Goodrich-Gulf Chemicals. Mathhews, who joined the firm in 1955, will have offices at Cleveland, Ohio.

Recent additions to the staff of Procter & Gamble are: **James Frisa** and **Gerald K. Saul**, Development Department of the Toilet Goods Division.

The board of directors of Layne & Bowler, Memphis water well drilling firm, chose **C. E. Ponkey** as president. He succeeds **W. H. Reeves**, who retires after 52 years with the company.

R. J. Waugh appointed general manager of The Lummus Co., Canada, Ltd., in Montreal. Waugh first joined the firm in England in 1951.

Jack A. Gerster, University of Delaware faculty member, one of the guest lecturers at Humble Oil & Refining's annual series on science and engineering at Baytown, Texas. His topic: *Azeotropic and Extractive Distillation.*

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people in marketing

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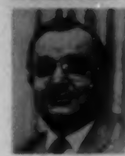


Three vice presidents named by Fluor Corp. in a major reorganization of its sales division. (Left, top to bottom.) **James P. Kneubuhl** is in charge of utility Sales, **George H. Dieter**, foreign sales and **David S. Tappan**, domestic sales. Kneubuhl has risen successively in the organization since joining it in 1941; Dieter and Tappan have been with Fluor since 1940 and 1952 respectively. The three men will be headquartered in the Los Angeles, Calif., office.

K. Frank Kennedy heads Pittsburgh Corning's new office in Montreal, Canada as general manager. Kennedy, a native of Ontario, has been with Pittsburgh Corning for five years, until now in the Boston, Mass. area.

W. C. King appointed director market research and economic analysis, Petrochemical Department of Gulf Oil. King, who has been connected with the firm since 1948, will continue to be located at the general offices in Pittsburgh, Pa.

Robert C. Hickerson becomes chemical market development manager of Tennessee Products & Chemical. He started with TP&C in 1950 on the research staff, and before assuming his present post was chemical products development manager for the Nashville company.

William A. Barnwell, Jr. leaves Dow Chemical to become sales representative for Baker Perkins, Inc. Chemical Machinery Division at Saginaw, Michigan.

David B. Roberts joins Atlantic Research Corp. sales staff as technical liaison engineer for the Alexandria, Virginia firm.

Donald J. Collins and **Richard I. Goodkind** advanced to vice president of marketing and administration, respectively, by Tennessee Products & Chemical. Collins moves up from general sales manager, while Goodkind was formerly administrative assistant to the president of the Nashville, Tennessee, firm.

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Leon W. Miller, director of chemical sales for Allied Chemical Plastics & Coal Chemicals Division, elected to the Board of Directors of the New York Board of Trade. Miller, who has spent his entire 43 year business life with Allied Chemical, previously held various executive posts on the Board of Trade.

Carlisle Chemical Works appoints **Donald S. McKenney** sales manager, and **Harold E. Klotz** works manager of Carlisle Division in Reading, Ohio.

Horace F. Richter, Jr. named to the newly created post of sales coordinator at Fischer & Porter Co., Hatboro, Pa. Richter has been with the firm for 19 years.

William R. Lucas new manager, regional chemicals sales office of Atlas Powder in Chicago. **Edward M. Simon, Jr.** succeeds him as assistant manager of the New York office.

Ray J. Ferree and **John K. Campbell** in new positions with National Lead. Ferree is special representative of technical sales and promotion of the metal protective paint pigment, M50; Campbell is manager of Pigments and Chemicals Division, St. Louis and Southwestern branches. Both are many year veterans with the company.

E. P. Additon appointed manager, contracts and sales promotion, Chemical Plants Division, Blaw-Knox. The new post brings him to Pittsburgh from the Division's office in Haddon Heights, N. J. where he served as district sales engineer.

John J. Mahoney and **Frank L. Cioffi,** consulting engineers, have taken new offices at Newark, N. J., moving from New York City, their previous location. Mahoney previously was chief engineer at Foster D. Snell, while Cioffi was chief structural engineer at Chem-Flow Designers.

Morton Salkind named account executive at Molesworth Associates, technical public relations and advertising agency. Salkind had been connected *Chemical and Engineering News* for several years, most recently as associate editor in the New York office.

NECROLOGY

John Stauf, district manager northeast district, Chemical Department, McKesson and Robbins. Long active in the industry, Stauf joined McKesson and Robbins in 1952, after 33 years with Allied Chemical.

Paul Weeks Litchfield, 83, honorary chairman of the board for Goodyear Tire & Rubber. Known as "dean of America's rubber industry," Litchfield retired in October after 58 years with the Company. He had been chairman of the board and chief executive officer for the firm. Litchfield played a major part in the synthetic rubber production program during World War II, and had received numerous awards in recognition of his contributions.

future meetings

1959—MEETINGS—A.I.Ch.E.

• Storrs, Conn. August 9-12, 1959. Univ. of Conn. **A.I.Ch.E.-A.S.M.E. Heat Transfer Conferences.** Prog. Chmn.: M. T. Cichelli, Eng. Research Lab., DuPont, Wilmington, Del.

• Austin, Tex. Sept. 9-11, 1959. Univ. of Texas **Mid-West Conf. on Fluid & Solid Mechanics.** Co-sponsored by U. of Tex., **A.I.Ch.E.** & others. Tech. Chmn.: M. J. Thompson, U. of Tex. Complete MS by June 1, 1959.

• St. Paul, Minn., Sept. 27-30, 1959. Hotel St. Paul. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: A. J. Madden, Jr., Univ. of Minn. **Mixing**—J. Y. Oldshue, Mixing Equip. Co., Inc., P. O. Box 1370, Rochester 3, N. Y. **Size Reduction**—J. W. Axelson, Johns-Manville, N. J. **Missile Construction Materials**—B. M. Landis, Missile Div., Lockheed Aircraft, Palo Alto, Calif. **Physical Properties of Liquids**—S. E. Isakoff, DuPont Co., Eng. Dept. Expr. Sta., Wilmington, Del. **Molecular Engineering**—M. Boudart, Princton U., Chem. Eng. Lab., Princeton, N. J. **Chemical Economics as a Unit Process**—M. H. Baker, 1645 Hennepin Ave., Minneapolis 3, Minn. **More Research for Your Dollars**—T. S. Mertes, Sun Oil Co., 1608 Walnut St., Philadelphia 3, Pa. **Process Control**—I. Lefkowitz, Case Inst. of Techn., Cleveland, Ohio. **Chemical Warfare**—Co-Chmn.: L. E. Garono & E. J. Gruen, Army Chem. Corps, Bldg. 250, Baltimore, Md. **Safety in Air and Ammonia Plants**—W. A. Mason, Dow Chem. Co., Midland, Mich. **Management of New Product Development**—L. B. Hitchcock, Consultant, 60 East 42 St., New York 17, N. Y. **The Chemical Engineer and Professional Societies**—C. R. Ringham, Phillips Petroleum Co., Bartlesville, Okla. **Axial Dispersion in Chemical Engineering Problems**—J. R. Fair, Jr., Monsanto Chem. Co., Sta. B, Dayton 7, O. **Coalescence**—R. C. Kintner, Dept. Ch.E., Ill. Inst. Tech., Chicago 16, Ill. **Student Program**—A. G. Fredrickson, Chem. Eng. Dept. U. of Minnesota, Minneapolis, Minn. **Selected Papers**—W. E. Ranz and H. S. Isbin, Dept. of Ch.E., U. of Minn., Minneapolis, Minn.
Deadline for papers: May 27, 1959.

• San Francisco, Calif., December 6-9, 1959. Sheraton Palace. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn.: C. R. Wilke, Div. of Chem. Eng., Univ. of Calif., Berkeley, Calif. **Process Dynamics**—E. F. Johnson, Dept. of Chem. Eng., Princeton U., Princeton, N. J. **Operations Research**—R. R. Hughes, Shell Dev. Co., Emeryville 8, Cal. **Progress and Problems in Jet and Rocket Combustion**—C. J. Marsel, NYU, University Heights, New York 53, N. Y. **Secondary Oil Recovery Methods**—F. H. Poettman, Ohio Oil Co., Littleton, Colo. **Financing in the Chemical Industry; Fundamental Aspects of Chemical Engineering in the Pulp and Paper Industry**—J. L. McCarthy, Dept. Chem. Eng., U. of Washington, Seattle, Wash. **Turbulence and Turbulent Mixing**—T. Baron, Shell Devel. Co., Emeryville, Cal. **Electro-Chemical Engineering**—C. W. Tobias, Dept. Chem. Eng., U. of Cal., Berkeley, Cal. **Outlook for National Resources**—C. Meyer, U. of Calif., Berkeley, Calif. **Quality Criteria for Catalytic Cracking Stocks & Methods of Preparation**—W. W. Kraft, Lummus Co., 385 Madison Ave., N. Y. 17, N. Y. **Student Program**—D. M. Mason, Stanford U., Calif. **Selected Papers**—M. Manders, Union Oil Co., Rodeo, Calif.
Deadline for papers: August 6, 1959.

1959—Non-A.I.Ch.E.

• East Lansing, Mich. June 10-12, 1959. Kellogg Center Bldg., Mich. State U. Anal. Instr. Div., **ISA. 2nd. International Symposium Gas Chromatography.**

• White Sulphur Springs, W. Va. June 11-13, 1959. The Greenbrier, **87th. Ann. Meeting MCA.**

• University Park, Pa. June 14-18, 1959. Penn. State. **Seminar on Air Pollution Abatement by Electrical Precipitation.**

• Los Angeles, Cal. June 22-26, 1959. Statler Hilton. **52nd. Ann. Tech. Session, Air Pollution Control Assoc.**

• Atlantic City, N. J. June 22-26, 1959. Joint **ASEE-ASTM Symposium on Education in [Engineering] Materials.**

• New London, New Hampton, Meriden, (all) N. H. 12 weeks; June 15-Sept. 4, 1959. **Gordon Research Conferences** on fundamentals of engineering and science. Ref. to: W. George Parks, Conf. Dir., U. of Rhode Island, Kingston, R. I.

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• Berkeley, Cal. Sept. 2-4, 1959. U. of Cal. **Cryogenic Engineering Conference;** limited to technical aspects of field only below 150°K (—190°F). Abstr. deadline: June 1; to K. D. Timmerhaus, Secy. Cryo. Eng. Conf., Dept. Ch.E., U. of Colo. Boulder, Colo.

1960—MEETINGS—A.I.Ch.E.

• Atlanta, Ga. Feb. 21-24, 1960. Hotel Biltmore. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: F. Bellinger, Georgia Tech., 225 North Avenue N. W., Atlanta 13, Ga. **Kinetics**—C. D. Holland, Chem. Eng. Dept., Texas A&M. College Sta., Texas. **Pesticides**—(2 sessions) D. J. Porter, Diamond Alkali, Box 348, Painesville, Ohio. **Nuclear Feed Materials Processing**—D. S. Arnold, Nat'l Lead, P. O. Box 158, Mt. Healthy, Cincinnati 31, O. **Petroleum, Turpentine, and Solvents; Rubber and Plastics Applied to Textile Fibers:** John Warner Chem. Div., Goodyear Tire & Rubber, 1485 E. Archwood Ave., Akron 16, O. **Bioengineering-Radioisotopes; Rockets and Missiles**—R. B. Filbert, Jr., Battelle Mem. Inst., 505 King Ave., Columbus, O. **Engineering Education; Mineral Engineering**—W. A. Koehler, West Virginia U., Morgantown, W. Va. **Fundamentals; Selling; By and To Small Plants**—J. T. Costigan, Sharples Corp., 501 5th Ave., New York 17, N. Y. **Filtration through Porous Media**—F. M. Tiller, Dean Coll. of Eng., U. of Houston, Houston 4, Tex. **Sterilization of Air & Food**—W. B. Harrison, Ga. Tech. **Air Pollution; High Pressure & High Temperature Technology.**
Deadline for papers: Sept. 21, 1959.

• Mexico City, Mexico, June 19-22, 1960. Hotel Del Prado. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: G. E. Montes, Nat'l Petrochemical Corp., P.O. Box 109, Tuscola, Ill. **Chemical Engineering in Latin America**—John Mayurnik, Grace Chem. Co., 3 Hanover Square, New York 4, N. Y. **Petroleum Production**—F. W. Jessen, Dept. Petroleum Eng., U. of Texas, Austin, Texas. **Minerals and Metals**—D. B. Coghlan, Foote Mineral Co., Lancaster Ave., Berwyn, Pa. **Distillation Equipment**—R. Katzen, 3735 Dogwood Lane, Cincinnati, O. **Biochemicals and Foods**—E. L. Gaden Ch.E. Dept., Columbia U., New York 27, N. Y. **Selected Papers.**
Deadline for papers: January 19, 1960.

• Tulsa, Okla., Oct. 2-5, 1960. Hotel Mayo. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: K. H. Hachmuth, Phillips Petroleum Co., Bartlesville, Okla **Foams—Their Use and Control**—C. S. Grove, Jr., Syracuse U., Collendale, Syracuse 10, N. Y. and R. L. Tuve, U. S. Naval Resch. Lab., Washington 25, D. C. **Computers as Management Tools**—R. Cziner, Grace Chem. Co., 3 Hanover Square, New York 4, N. Y. **Chemical Reactions Induced or Modified by Radiation**—J. J. Martin, Dept. Chem. Eng., U. of Mich., Ann Arbor, Mich. **Conservation & Utilization of Water**—F. J. Lockhart, Ch.E. Dept. U of So. Cal., L. A. 7, Cal. **Processing Agricultural Products**—A. Rose, Tex. Eng. Exp. Sta., Tex. A&M, Coll. Sta., Tex. **Natural Gas & Natural Gas Liquids**—R. L. Huntington, Ch.E. Dept., U. of Okla. **Transport Processes in Petroleum Recovery; Advances in Refinery Technology, Petrochemicals, Pilot Plants and Scaleup; Corrosion and Materials of Construction; Statistics and Numerical Methods Applied to Engineering; Comparative Economics of Various Energy Sources for Process Heat; Safety in Air and Ammonia Plants; Safety in Refinery and Natural Gasoline Plants; Non-Newtonian Fluid Mechanics; Air Cooling; Student Program.**
Deadline for papers: May 2, 1960.

• Washington, D. C., Dec. 4-7, 1960. Statler Hotel. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn.: D. O. Myatt, Atlantic Research Corp., Alexandria, Va.
Tentative Program framework: **Chemical Engineering in Govt. Programs.** Agency Oriented: **Nuclear Energy, Health and Education; Agriculture; Foreign Assistance Programs; Resource Development; Utilization and Reclamation; Naval Warfare Technology; Land Warfare Technology; Chemical Warfare, and Basic Research.** Subject Oriented: **Doing Business with the Government; Fluid Particles and Aerosols; Combustion; Materials Deterioration; New Process Techniques; Unsteady State Instrumentation; Computer Control of Processing Units; Missiles and Rockets; Design Techniques for Very Large Systems; Information and Communication; Characteristics of Portable and Expendable Plants and Equipments.**
Deadline for papers: July 4, 1960.

1960—MEETINGS—Non-A.I.Ch.E.

• Adelaide, So. Australia, Feb. 16-19, 1960. Austral. Inst. Min. & Metall. **Wet Processing of Minerals & Industrial Products.** Deadline for 500-word synopsis, Apr. 30, 1959 (late returns accept. from overseas) to: Aus. I.M.M. Sympos. Secy. c/o So. Austral. Dept. Mines, Osman Place, West Thebarton, Adelaide, S. A.

• London, England. Three days, Spring, 1960. International Symposium **Distillation: Fundamentals; theory & practice.** Paper summaries by June 1, 1959 to: Secy. Institution of Chem. Engrs., 16, Belgrave Square, London, S.W. 1, Eng.

• Moscow, USSR, June 1960. 1st Congress of International Fed., Automatic Control. To cover areas of **Theory, Hardware & Applications of Automatic Control.** U.S. participation sponsored by American Automatic Control Council. Affiliated societies: **A.I.Ch.E., ASME, AIEE, IRE, ISA.** A.I.Ch.E. Chmn.: D. M. Boyd, Universal Oil Prods., Des Plaines, Ill. Completed papers by July 15, 1959.

1961—MEETINGS—A.I.Ch.E.

• New Orleans, La. Feb. 5-8, 1961. Jung Hotel. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: H. L. Malakoff, Petroleum Chem. P.O. Box 6, New Orleans 6, La. **Kinetics of Catalytic Reaction; Brainstorming Technical Problems; Petrochemicals—Future of the Industry on Gulf**

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CHEMICAL ENGINEERS—Excellent opportunities offered to qualified applicants. Chemical Engineers with BS degree to do process and production development work. 0-10 years' experience, draft exempt preferred. Good salaries, working conditions, and extra benefits for employees of Hercules Powder Company. Write or apply at Employment Office, Hercules Powder Company, Radford Arsenal, Radford, Virginia.

HEAT TRANSFER ENGINEER—At least three years' experience in Thermal Design of Process Heat Exchangers. Chemical or mechanical engineering degree required. Salary and assignment commensurate with experience and ability. Give full details in your letter. Location Eastern Penn. Box 3-5

ACADEMIC POSITION—Chemical Engineering. The Department of Chemical Engineering of the University of New Mexico, Albuquerque, New Mexico, solicits applications for a staff position of instructor or assistant professor rank. Inquiries should be addressed to: Dr. T. T. Castonguay, Chairman, Chemical Engineering Department, University of New Mexico.

SITUATIONS WANTED

A.I.Ch.E. Members

CHEMICAL ENGINEER—M. Ch.E. Three years' petroleum process design. Desire challenging opportunity along process design, development, or improvement. Tau Beta Pi. Age 27. Married. East Coast or California preferred. Box 5-5.

CHEMICAL ENGINEER—Ph.D., P.E., Eight years diversified industrial and academic research; part-time faculty, metropolitan university. Publications. Sigma Xi, PLU. Desire relocation with boader professional growth potential. Box 6-5.

CHEMICAL ENGINEER-CHEMIST—B.A. Chemistry 1954. S.M. Ch.E., M.I.T. 1956. Three years' extensive experience industrial chemicals, lube oils, additives, polymer rheology Supervisory experience. Present salary range $8500. Seeking challenging position in plastics industry in metropolitan New York-New Jersey area. Box 7-5.

B. Ch.E. 1952, M. Ch.E. 1955. Four years' experience special fuels synthesis and evaluation. Three years' experience thermodynamic design, development, and testing ramjet combustion systems. Desire challenging technical and administrative position in N.Y.C., area. Box 8-5.

RESEARCH DIRECTOR—D. Eng. Sc. 1944. Specialist coordination creative developments: foods, plastics, drugs, petroleum and fatty acids; project appraisals, pilot planting manufacturing improvements. Valuable fundamental researches based twenty years outstanding consulting background. Sigma XXI, honors, lecturer, Tau Beta Pi, publications. Box 9-5.

GRADUATE ENGINEER—M.S. Ind. Mgt., B.S. Ch.E., A.B. Lib, Arts. Age 34, family. Two years' diversified experience. Desire staff position in marketing or economic planning, working with people. Florida location preferred—others considered. Box 10-5.

CHEMICAL ENGINEER—INSTITUTE MEMBER, 48, HEALTHY AND UNHANDICAPPED, MS DEGREE M.I.T. SIXTEEN YEARS' EXPERIENCE, TEN IN PROCESS, PROJECT WORK. CAN FURNISH $25,000 POSSIBLY MORE CAPITAL. ANY PROPOSITIONS? BOX 11-5.

CHEMICAL ENGINEER—B.Ch.E., M. Sc. Four years' experience in supervision of diverse pilot plant operations. Seeking position of greater responsibility and opportunity for advancement. Some background in business administration. Positions requiring shift work will not be considered. Eastern location prefered. Box 12-5.

CHEMICAL ENGINEER—B.Ch.E. 1952, Age 28, veteran, married. Five years' experience in process design and economic evaluation in petroleum and chemical industry. Desire responsible position in process engineering or development. Box 13-5.

A. I. Ch. E. candidates

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions. These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before June 15, 1959, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

MEMBERS

Backstrom, H. A., *Warren, Pa.*
Dunbar, Robert B., Jr., *Martinsville, N. J.*
Eddy, Henry D., *Ross, Calif.*
Grubb, H. V., *Atlanta, Ga.*
Heller, Austin N., *Ramsey, N. J.*
Himmelberger, Franklin, *Allentown, Pa.*
Hukill, Emory C., Jr., *Cleveland, Ohio*
Johnson, Robert T., *Lake Jackson, Tex.*
Kobayashi, Riki, *Houston, Tex.*
Kuhre, Calvin J., *Emeryville, Calif.*
Lerner, Daniel, *Clifton, N. J.*
McGhee, William J., *Cincinnati, Ohio*
Rounds, Hugh G., *Twin Falls, Idaho*
Samfield, Max, *Durham, N. C.*
Solomon, Julius H., *Stamford, Conn.*
Stack, Vernon T., Jr., *Newtown Square, Pa.*
Theoharous, Lewis, *Ivorydale, Ohio*
Urbain, Walter M., *Chicago, Ill.*
White, D. A., *Houston, Tex.*
Yates, Robert S., *Webster Groves, Mo.*

ASSOCIATES

Brandon, David B., *Los Angeles, Calif.*
Couvillon, Alvin B., Jr., *Groves, Tex.*
Degner, C. E., *Whiting, Ind.*
Dillon, John, W., *Dalton, Mass.*
Gross, Phillip W., Jr., *Shorewood, Wis.*
Klein, Frank G., *Philadelphia, Pa.*
Micoh, Carlo O., *Wilmington, Del.*
Morris, Edward J., III, *Corpus Christi, Tex.*
O'Flaherty, Stephen J., *Argo, Ill.*
Ruder, Joseph M., *Brighton, Mass.*
Rutledge, Gerald D., *Long Beach, Calif.*
Schmitt, R. J., *Monroeville, Pa.*
Schnelle, Karl B., Jr., *Nashville, Tenn.*
Shively, Robert E., *E. Stroudsburg, Pa.*
Shook, Percy J., *Charleston, Miss.*
Simonds, Milton R., *Marcus Hook, Pa.*
Skripek, Milan, *Inglewood, Calif.*
Tarleton, Jesse S., *Wilmington, Del.*
Weigers, Gordon U., *New Orleans, La.*
Willard, John L., *Chicago, Ill.*
Willison, William M., *Chatham, N. J.*
Wood, Ross J., *Seattle, Wash.*

AFFILIATE

Mertz, Boyd A., *Tonawanda, N. Y.*

First commercial shipment of enriched uranyl sulfate solution has gone to West Germany, will be used for research in two West Berlin universities. The material, valued at $30,000, and enriched to approximately 19.9% U-235, was made by the Special Metals Division of Mallinckrodt Chemical Works, St. Louis. Special packaging for the shipment consisted of heavy-walled polyethylene bottles enclosed in water-tight steel tubes. As a further precaution, prior to air shipment, the steel tubes were welded into the center of a steel framework known as a "birdcage."

SITUATIONS WANTED
A.I.Ch.E. Members

CHEMICAL ENGINEER—B.S.Ch.E., 1956. Age 24, single. Three years' experience in process development with large firm. Desire production or development position with small or medium firm. Midwest preferred. Box 14-5.

CHEMICAL-INDUSTRIAL ENGINEER—M.S.Ch.E., age 28. Four years' manufacturing trouble shooting; statistical applications to cost, labor, product control. Desire opportunity with small chemical firm in process engineering, technical service, production supervision. N. Y., N. J., area. Box 15-5.

EXECUTIVE ENGINEER—D. Eng. Sc., 1942. Expert in management, creative development, process designing, facilities planning: chemicals, foods, drugs, plastics; domestic and foreign. Project appraisals, budget planning, economic studies, cost reduction, quality improvement. Box 16-5.

CHEMICAL ENGINEER seeks management or supervisory position in engineering or operating department of small to medium size company. Prefer Northeast. Now live in New Jersey. Twenty years' design, development, plant start-up, technical editing, customer contact, in chemical, fertilizer, low temperature fields. Box 17-5.

MATHEMATICAL ENGINEER—34. B.S. Ch.E. M.S. Chem., R.P.E., Fourteen years' experience, starch, petroleum, thermodynamics, electronic computers, fluid flow, and management. Patents, publications, oral and written presentation. R. L. McIntire desire realistic technical assignment. Box 18-5.

R & D SUPERVISOR—MS ChE. Age 39. Fifteen years' experience in process development, market development, organic synthesis of intermediates, polymers, pesticides. Desire position in process development or economic evaluation. Presently earning $12,200. Box 19-5.

ADVANCE INFORMATION

The Situations Wanted portion of this Classified Section is preprinted and mailed a few days in advance of publication, to Employment Directors. Send names of individuals who should be on mailing list to: Miss E. Adelhardt, Chemical Engineering Progress, 25 W. 45th Street, New York 36, New York.

A Preprint of all SITUATIONS WANTED notices is mailed directly monthly to thousands of personnel and recruitment officers nationally.

CLASSIFIED SECTION RATES

Advertisement in the Classified Section are minimum of four lines accepted. Box number counts as two words. Advertisements payable in advance at 24c a word, with a average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. Members may enter more than one insertion at half rates. Prospective employers and employees in using the Classified Section generally agree that all communications should be acknowledged as a matter of courtesy but recognize circumstances where secrecy must be maintained. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 10th of the month preceding publication.

ADDITIONAL RECRUITMENT ADVERTISEMENTS

See additional display advertisements on pages 30 and 135.

Classified . . .
EQUIPMENT SECTION

"Education on Process Control", a symposium report by the A.I.Ch.E. Educational Subcommittee for Process Control will interest those whose mission it is to train young chemical engineers in the important field of process control. Includes: The Needs of Industry for Persons Trained in Process Control and Process Dynamics; an Undergraduate Course in Automatic Process Control and Process Dynamics; a Graduate Course in Automatic Process Control and Process Dynamics in Chemical Engineering; the Laboratory Period in the Process Control Course; Training in Industry for Process Control and Process Dynamics; Conclusions and Recommendations. Plastic bound, 87 pages, 8½" x 11", $1.50.

future meetings

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Coast: Solids; Future Processing Technologies in the Petroleum Industry; Education and Professionalism; Mathematics in Chemical Engineering; Liquid—Liquid Extractions; New Processes in the Area; Water from Sea Water; Materials of Construction.
Deadline for papers: Sept. 5, 1960.

• Cleveland, O., May 7-10, 1961. Sheraton-Cleveland. A.I.Ch.E. National Meeting. Tech. Prog. Chmn.: R. P. Dinsmore, Goodyear Tire & Rubber Co., Akron 10, O.

Unscheduled Symposia

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.

Computers in Optimum Design of Process Equipment: Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.

Solar Energy Research: J. A. Duffie, Director of Solar Energy Laboratory, Univ. of Wisconsin, Madison, Wis.

Hydrometallurgy—Chemistry of Solvent Extraction: G. H. Beyer, Dept. of Chem. Eng., Univ. Mo., Columbia, Mo.

Process Dynamics as They Affect Automatic Control—D. M. Boyd, Universal Oil Prods., Des Plaines, Ill.

Author Information

Procedure in submitting papers:

1. Obtain four copies of "Proposal to present a paper before the A.I.Ch.E." plus one copy of "Guide to Authors" from Secretary, A.I.Ch.E., 25 West 45th St., New York 36, N. Y.
2. Send one copy of completed form to Technical Program Chairman for meeting selected from above list
3. Send another copy to Norman Moresh, Titanium Div., Natl. Lead Co., So. Amboy, N. J. (Ass't. Chmn. Program Comm.)
4. Send third copy to Editor, Chemical Engineering Progress, 25 West 45th St., New York, 36, N. Y. Paper will automatically be considered for possible publication in A.I.Ch.E. Journal.
5. If desired to present paper in a selected symposium, send fourth copy to chairman of the symposium.
6. Prepare six copies of manuscript. Send all six to Symposium chairman or the Selected Papers chairman, whichever is appropriate.

A $350,000 U.S. grant toward the cost of a research reactor for Norway has been approved by the AEC. The zero-power, pool-type facility, fueled with natural uranium and moderated and cooled with heavy water, will be used by the Institutt for Atomenergi, a Norwegian Government agency. Fabrication of the reactor will be handled by the IFA or by private Norwegian firms, while some of the equipment for the reactor as well as five tons of heavy water will be bought in the U.S.

INDEX OF ADVERTISERS

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Chicago 4—Martin J. Crowley, Jr., Dist. Mgr.; Robert Kliesch, Dist. Mgr.; 53 West Jackson Blvd., Room 504, HArrison 7-3760.

Cleveland 15—Harry L. Gebauer, Dist. Mgr., 434 Bulkley Bldg., SUperior 1-3315.

Pasadena 1, Calif.—Richard P. McKey, Dist. Mgr., 465 East Union St., RYan 1-0685.

Dallas 18—Richard E. Hoierman, Dist. Mgr., 9006 Capri Drive, Diamond 8-1229.

Birmingham 9, Ala.—Fred W. Smith, Dist. Mgr., 1201 Forest View Lane, Vesthaven, TRemont 1-5762.

News and Notes of A.I.Ch.E.

Care and Feeding of Students—Bob Nellums, Chairman of the St. Louis Section, has invited the senior members of the chemical engineering class at Washington University to be the guests of the St. Louis Section at one dinner meeting this spring. The students may select any meeting they wish. A copy of the section's program has been given to the Student Section. The idea of course is to interest these men in the activities of A.I.Ch.E. well before they graduate.

Ethics of recruiting—Council recently agreed with our representative on the Ethics Committee of Engineers' Council for Professional Development, Past President B. F. Dodge, that we accept the document "The Principles and Practices of College Recruiting," which tries to detail the ethical procedures to be used by employers and colleges. This is essentially the same statement that was issued by the American Society of Engineering Education. Should any of the members wish a copy, we suggest that they write to E.C.P.D.

Russian translations—At Atlantic City, Council authorized the Secretary to enter into suitable contracts with the National Science Foundation and others to publish translations of Russian journals in chemical engineering. Work is now underway to see what the need is in the field and, as we progress and have something positive to report, we will use these columns to do so. The Institute is fortunate in having on its staff Waldo Hoffman, who reads Russian. He will spearhead most of the effort in this area.

United Engineering Center Campaign—As of this writing, April 15, A.I.Ch.E. is 95% of the distance toward its goal of $300,000 from members. Only $12,897.07 is needed to fill its quota and, with the final drive being put on by many of the Local Sections, it is my hope that by the time I write the June *News and Notes* the Institute will have achieved 100%.

A.I.Ch.E. has sixteen sections that have more than met their quotas and fifteen sections very close to their quotas. We expect to run a news story about the campaign at its completion and will give the membership more information about the sections and the campaign chairmen who have helped in this outstanding drive.

Some of the sections that have closed their campaigns continue to send in contributions. Among these recently have been the following sections: Columbia Valley, East Tennessee, New Haven, Northeastern New York, Rochester, St. Louis, and Akron.

The campaign total collection now stands at $6,530,600, and the Industrial Campaign Committee feels certain that it is going to bring in more than its quota of $5,000,000.

For the members of A.I.Ch.E. who still intend to contribute to the creation of this worldwide headquarters for engineering, this is the time to do it; we want to get the extra $13,000 we need to reach our quota as quickly as possible. The good work for the campaign belongs to Sid Kirkpatrick, who by the time this page is published will have just retired from *Chemical Engineering* and McGraw-Hill; to Walt Whitman, Past President of the Institute and Chairman of the Chemical Engineering Department at M.I.T.; and to Don Katz, President of A.I.Ch.E. and Chairman of the Chemical Engineering Department at Ann Arbor.

Opinion from South Texas — The South Texas Section of A.I.Ch.E. under a special committee headed by E. M. Jones and Irving Leibson and aided by ten A.I.Ch.E. members at Humble recently surveyed opinions of A.I.Ch.E. members on certain professional problems and on activities that A.I.Ch.E. might undertake. A report of this survey was given by J. J. McKetta at the recent Council Meeting at Atlantic City, at which Matt Jones also discussed the questionnaire, and while we cannot give the complete report in these columns, the following results are of great interest to members and to other Local Sections.

On the unification of the entire engineering profession in one engineering association, the vote just about split between yes and no; as far as registration of chemical engineers is concerned, the vote was 62% in favor and 26% against; and when asked about collective bargaining for engineers by "professional" unions 6% said yes and 89% said no.

Then the group took the skin off an old chestnut that has been around for years. It asked whether the national A.I.Ch.E. was dominated by members of top corporate management; 36% said it was, 43% said it was not, and 21% said that they did not know. Then in a companion question these same people were asked whether they thought that this situation, if so, was detrimental to the Institute, and 26% said yes, 53% said no, and 20% did not know. The surveyors then posed a similar question, asking whether the respondents thought that A.I.Ch.E. was dominated by chemical engineering professors; here 23% said yes, 58% said no, and 19% did not know. Asked whether they considered academic domination detrimental to the Institute—assuming that it existed—14% said yes, 63% said no, and 23% said they did not know.

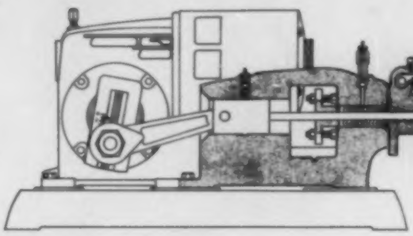
A.I.Ch.E. got a clean bill of health on support of chemical engineering education, but the majority felt that it could do more counseling of chemical engineering graduates in their early professional years. Eighty-nine percent thought Institute programs were providing interesting technical and nontechnical meetings for the continuous professional development of the members. The cooperation of A.I.Ch.E. with other engineering and scientific societies received a highly satisfactory score, as did its publications, but the A.I.Ch.E. public relations program devoted to telling the public about chemical engineering was thought to be inadequate. The Institute's standards of ethical conduct were considered satisfactory, as was the awards program for recognizing technical and professional achievements.

F.J.V.A.

HOW TO METER ACIDS ACCURATELY AGAINST PRESSURE

Corrosive liquids present two major obstacles to achieving maximum metering accuracy, economy, and safety. For one thing, corrosion can introduce an intolerable ever-changing volumetric error. For another, corrosive liquids must be retained by the pump at all times. Leakage can endanger personnel and necessitate the premature replacement of pump parts and associated equipment.

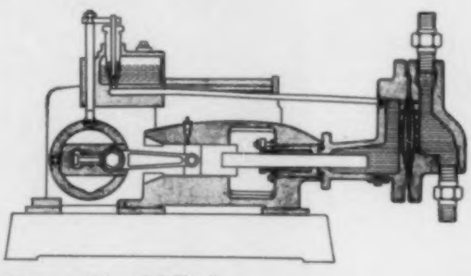
But both obstacles can be successfully overcome. First by choosing the right pump for the metering job at hand. Second, by making sure that all wetted parts of the pump chosen are inert to the liquid being metered. Here are some ideas based on practical acid metering experience that may help you to choose the one best controlled volume pump for your metering needs.



Packed Plunger Pumps

For the majority of mildly corrosive liquids, low cost packed plunger pumps have proved themselves entirely adequate. Some thirteen materials of construction are *standard* on packed plunger pumps, running from cast iron to Hastelloy B and C, more than enough to satisfy mild corrosive metering requirements. Capacities to 2056 gph, pressures up to 50,000 psi.

An added tip: Standard Milton Roy motor driven pumps in corrosive service can be equipped with "catch-all" yoke type gland followers.

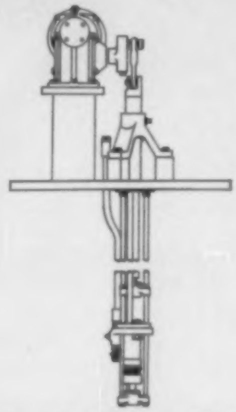


Diaphragm Liquid Ends

When the liquid to be metered is highly corrosive or otherwise dangerous, a controlled volume pump with diaphragm liquid end is the best choice. A plastic or stainless steel diaphragm positively separates the process liquid and the plunger. The plunger displaces a hydraulic fluid which in turn strokes the diaphragm to create pumping action through the ball checks. Consistently high accuracy is achieved through unique design features. As the illustration shows, positive mechanical action bleeds any air or vapor from the hydraulic side between strokes and corrects liquid volume if necessary. Internal liquid end design also automatically eliminates bubbles from the process liquid side.

Very often, a pump chosen for mild corrosive service is obsoleted by a process change specifying a more highly corrosive liquid. But this waste is neither necessary nor desirable. The diaphragm liquid end illustrated can easily be substituted for the conventional liquid end on any standard motor driven controlled volume pump, bringing the entire metering system up to date at little extra expense. *Designs of this type will handle up to 400 gph against heads to 2700 psi.*

Totally Immersed Liquid Ends



Special metering problems demand special pump designs. For example, acids with high vapor pressure or high specific gravity must be pumped with limited suction lifts and generally require suction heads. The ideal answer is the standard Mersemetric® controlled volume pump. Pump drive and motor are mounted on the tank top, but the liquid end is completely submerged to a depth of up to fourteen feet. This same design feature also eliminates the need for tank connections below liquid level, and permits chemicals to be metered *directly* from storage.

The maximum safety-minimum handling Mersemetric design is just about standard for metering sulfuric acid for demineralizer regeneration and pH control of cooling tower water and deaerator effluents. *Capacities up to 218 gph, pressures up to 1200 psi.*

The Acid Metering System

You can be fairly sure of making the right choice only if you consider *all* the factors. Here's a convenient checklist of a few points that are often overlooked:

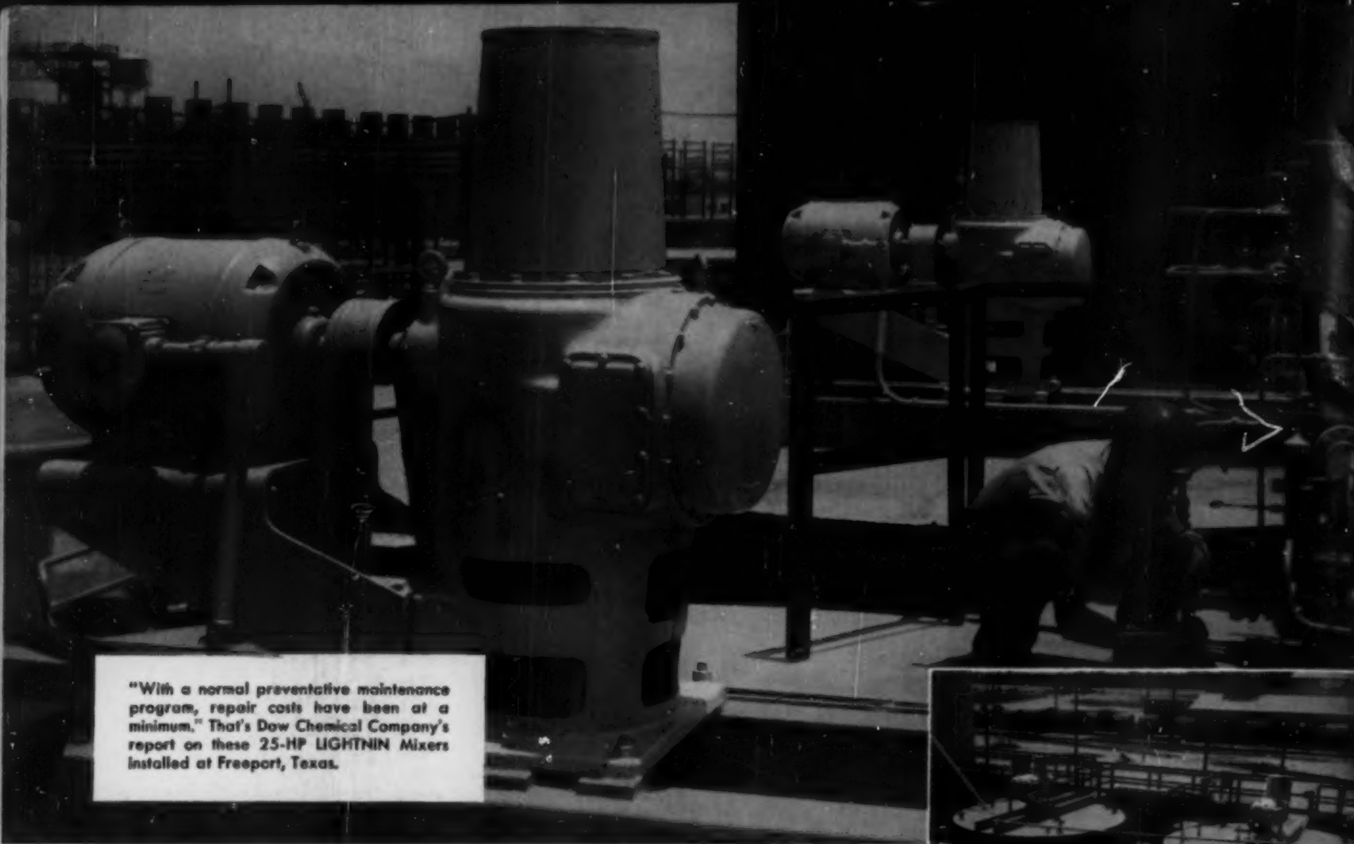
- Is the entire *system* corrosion-resistant . . . storage tank, suction and discharge piping, controlled volume pump, and relief valve?
- Have you thoroughly considered the physical properties of the liquid? High vapor pressure or high specific gravity liquids may demand a suction head.
- Have you considered plant and personnel safety under all possible conditions?
- Have you considered maintenance as well as first cost in determining the economics of the system?

If precision pumping of dangerous chemicals is one of your problems, look again to Milton Roy's 25 years of experience for your most economical solution. Write for a general introduction to controlled volume pumping in Bulletin 553-1. Milton Roy Company, 1300 East Mermaid Lane, Phila. 18, Pa.

milton Roy
CHEMICAL INSTRUMENTATION SYSTEMS

Controlled Volume Pumps • Quantichem Analyzers • Chemical Feed Systems

For more information, turn to Data Service card, circle No. 48



"With a normal preventative maintenance program, repair costs have been at a minimum." That's Dow Chemical Company's report on these 25-HP LIGHTNIN Mixers installed at Freeport, Texas.

PRIOR TO PURIFICATION, caustic is kept at uniform temperature, with help of mixing, in each of six 30,000-gallon tanks like these. LIGHTNINs also suspend sediment uniformly for easier removal.

How Dow holds mixing costs in line

Take a look at the size of Dow Chemical Company's Freeport, Texas, caustic soda plant—and you'll see why low operating costs for mixing equipment are vital.

No special research had to be done to determine what size mixers would handle this job best. Mixers were selected on the basis of unique pilot-run data on tap at MIXCO. Mixing results were fully predictable, and unconditionally guaranteed.

No steady bearings

Despite the 20-foot depth of the six 30,000-gallon tanks, there is no need for submerged bottom bearings on the shafts. Critical-speed data at MIXCO permitted accurate specification of overhung shafts adequately sized for the job, but not oversized.

A big factor in keeping maintenance cost down was the material specified for shafts and impellers—solid nickel. Engineers could freely select the best material for the job, because LIGHTNINS are available in any machinable alloy and with a wide choice of coverings.

On installation, substantial savings resulted from delivery of the LIGHTNINS fully assembled and aligned, ready to mount on the tanks without special construction.

Get these 3 vital savings

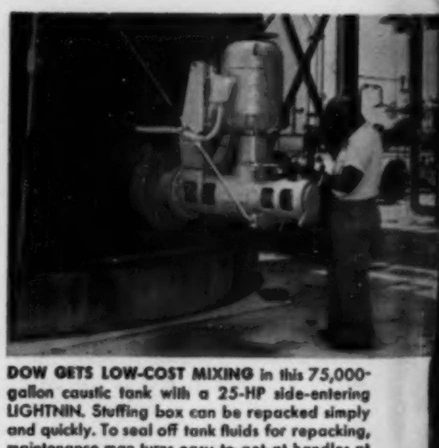
These economies are yours, too, when you choose LIGHTNINS for your fluid mixing operations.

You save design time with application data that's guaranteed accurate.

You save installation time because every LIGHTNIN reaches you as a "package," ready to install and run.

You keep saving on upkeep, with a host of mechanical features that minimize your service costs.

To get these savings for your processing, call in your LIGHTNIN Mixer representative. He's listed in Chemical Engineering Catalog. Or write us direct.



DOW GETS LOW-COST MIXING in this 75,000-gallon caustic tank with a 25-HP side-entering LIGHTNIN. Stuffing box can be repacked simply and quickly. To seal off tank fluids for repacking, maintenance man turns easy-to-get-at handles at outboard end of mixer.

What Mixing Operations are important to you? You'll find a wealth of information on fluid mixing in these helpful bulletins describing LIGHTNIN Mixers:

- ☐ Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP (B-102)
- ☐ Top entering; propeller types: ¼ to 3 HP (B-103)
- ☐ Portable: ⅛ to 3 HP (B-108)
- ☐ Side entering: 1 to 25 HP (B-104)
- ☐ Laboratory and small-batch production types (B-112)
- ☐ Condensed catalog showing all types (B-109)
- ☐ Quick-change rotary mechanical seals for pressure and vacuum mixing (B-111)
- ☐ LIGHTNIN CM Contactor for continuous processing (B-515)
- ☐ Confidential data sheet for figuring your mixer requirements (B-107)

Check, clip and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc., 199-e Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Avenue, Toronto 19, Ont.

For more information, turn to Data Service card, circle No. 5

Lightnin® Mixers

MIXCO fluid mixing specialists